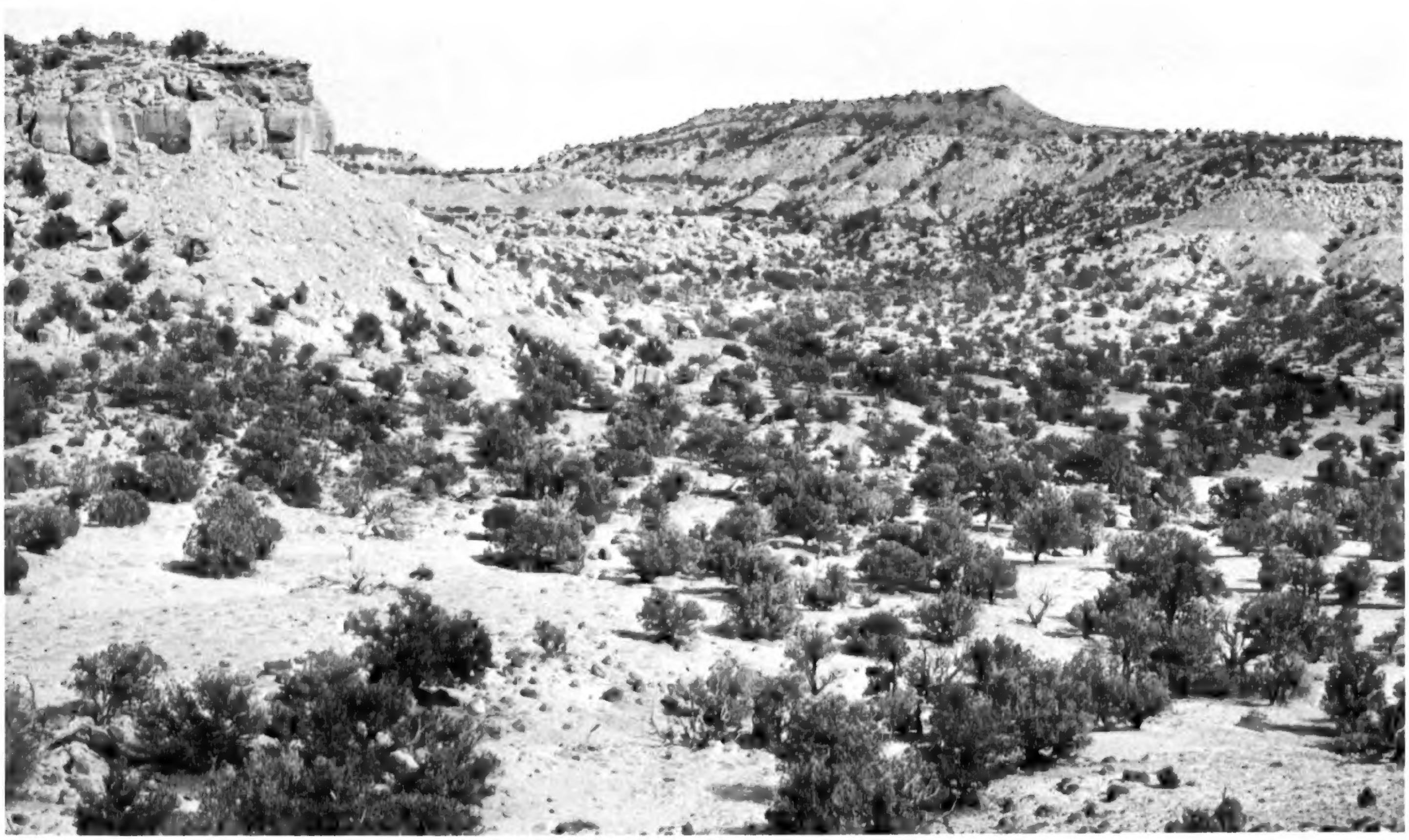
# SOIL SURVEY
# Carbon-Emery Area, Utah



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
and
UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Land Management
In cooperation with
UTAH AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1957–61. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the survey area in 1961. This survey was made cooperatively by the Soil Conservation Service, the Bureau of Land Management, and the Utah Agricultural Experiment Station as a part of the technical assistance furnished to the Price River Watershed, San Rafael, and Green River Soil Conservation Districts.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or can be purchased on individual order from the Cartographic Division, Soil Conservation Service, USDA, Washington, D.C. 20250.

# HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of the Carbon-Emery Area, Utah, contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, or other structures; and in judging the value of tracts of land for agriculture, industry, or recreation.

All the soils of the Carbon-Emery Area are shown on the detailed map at the back of this soil survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

## Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit and range site in which the soil has been placed.

Interpretations not included in the text can be developed by using the soil map and information in the text to group soils according to their limitations for a particular use. Translucent material then can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

*Farmers and ranchers* can learn about use and management of the soils in the section describing the soils and in the discussions of the capability units and range sites.

*Game managers, sportsmen, and others concerned with wildlife* will find information about soils and wildlife in the section "Use of the Soils for Wildlife."

*Engineers and builders* will find, under "Engineering Properties and Behavior of Soils," tables that show the estimated engineering properties of the soils and the effect of these properties on engineering practices and structures.

*Scientists and others* can read about how the soils were formed and how they are classified in the section "Formation and Classification of Soils."

*Newcomers to the Carbon-Emery Area* may be especially interested in the section "General Soil Map," where broad patterns of the soils are described. They may also be interested in the section "Additional Facts About the Carbon-Emery Area."

***Cover picture:*** **Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded. Steep rocky slopes in the background are not suitable for livestock grazing but are used by wildlife. Semi-Desert Stony Hills (Pinon-Juniper) range site.**

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# Contents



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# SOIL SURVEY OF CARBON-EMERY AREA, UTAH

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH UTAH AGRICULTURAL EXPERIMENT STATION

THE CARBON-EMERY AREA is in the east-central part of Utah in the canyonland part of the Colorado Plateau (fig. 1). This area is called Castle Valley, and in it are most of the cultivated soils in Carbon and Emery Counties, including those in the vicinity of Green River, Utah, about 50 miles east. A small part of the survey area is in Grand County. There is also a small area in the eastern part of Sevier County, Utah. Most of the survey area consists of noncultivated soils that surround cultivated areas. The total area of the survey is 478,473 acres, or about 748 square miles. The elevation ranges from about 4,000 to 6,500 feet. Price, the county seat of Carbon County, is near the north end of the area and is about 100 air miles southeast of Salt Lake City, Utah. Castle Dale, the county seat of Emery County, is about 30 miles southwest of Price.

Most of the Carbon-Emery Area consists of rolling hills, narrow valleys, mesalike remnants of old outwash plains, and steep, rough broken land. Adjoining the survey area on the north are the Book Cliffs, and on the west is the Wasatch Plateau.

The raising of beef cattle and sheep is the main source of agricultural income. The main industry is coal mining. Large deposits of coal are in Carbon and Emery Counties.

Dry climate, a shortage of irrigation water late in summer, and a short growing season often limit crop production. Where the growing season is short, the main crops are alfalfa, small grains, irrigated pasture, corn harvested for ensilage, and a small acreage of sugar beets. At Green River, where the growing season is longer, the soils are used also for watermelons, cantaloups, and corn harvested for grain.

About 98 percent of the grain and hay is fed to livestock on farms in the survey area. The rest is sold but is consumed by livestock in parts of Carbon and Emery Counties outside the survey area. The acreage from which hay is cut and that from which corn is harvested for ensilage and fodder is increasing. The acreage of total cropland harvested is decreasing, probably because of accumulated salts in the soils and the shortage of irrigation water. The proportion of total farm income derived from fruit and vegetables is decreasing.

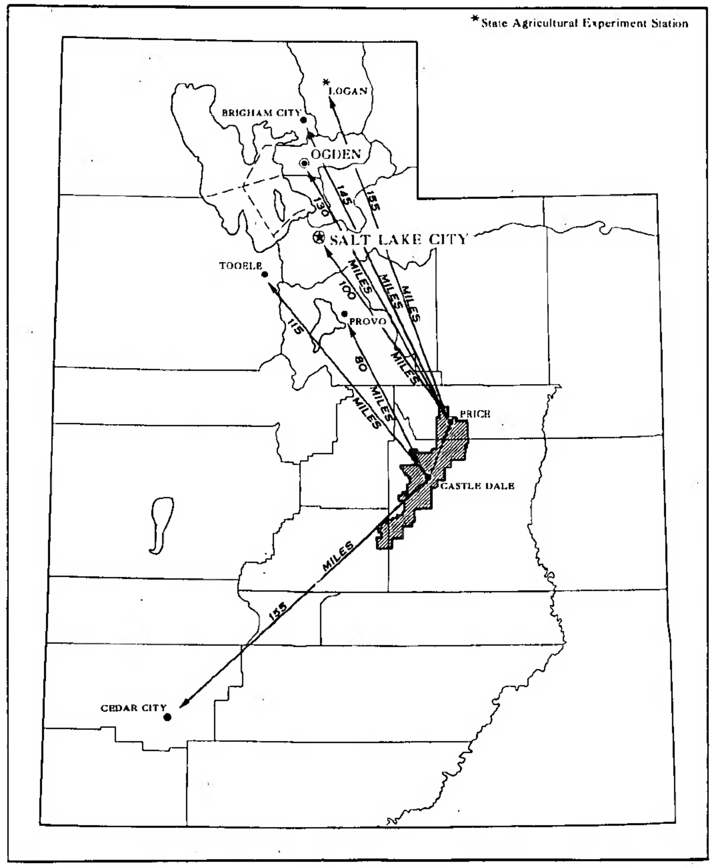


*Figure 1.*—**Location of the Carbon-Emery Area in Utah.**

In 1962 about 784 farms were in the Carbon-Emery survey area. The farms averaged about 916 acres, including both cultivated and range areas. About 48,766 acres, or about 10 percent of the survey area, is irrigated and is under some type of organized irrigation system. The irrigated acreage varies from year to year, depending on the supply of water. There is no dryfarming in the survey area.

All the irrigated land in the survey area is in private ownership, and about 40 percent of the rangeland is privately owned. The State and Federal governments

[1] T. B. HUTCHINGS, State soil scientist, Soil Conservation Service, and LEMOYNE WILSON, Utah Agricultural Experiment Station, reviewed and assisted in writing this manuscript; WARREN M. ARCHER, Soil Conservation Service, assisted with mapping of the survey area; and JAMES P. THORNE, soil scientist, Cooperative Soil Laboratory, Logan, Utah, made the chemical analyses.

own the rest of the rangeland. Lands most useful as habitat for wildlife comprise about 85,860 acres. Of this area, about 15 percent is in private ownership; the rest is in State and Federal ownership.

## *How This Survey Was Made*

Soil scientists made this survey to learn what kinds of soils are in the Carbon-Emery Area, where they are located, and how they can be used. They went into the area knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the area, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this soil survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Many soil series are named for a town or other geographic feature near the place where that soil was first observed and mapped. Killpack and Minchey, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Killpack loam and Killpack clay loam are two soil types in the Killpack series. The difference in texture of their surface layers is apparent from their names.

Some types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Killpack clay loam, 1 to 3 percent slopes, is one of several phases of Killpack clay loam, a soil type that ranges from nearly level to gently sloping.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this survey was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Minchey-Sanpete complex, 1 to 3 percent slopes.

Some mapping units contain more than one kind of soil in a pattern more open and less intricate than that of a soil complex. Such a mapping unit is called a soil association. A soil association differs from a soil complex in that its component soils can be mapped separately, at ordinary scales such as 4 inches per mile if practical advantages make the effort worth while. Separate mapping at ordinary scales is not possible for a soil complex. A soil association, like a soil complex, is named for the major soils in it, for example, Chipeta-Persayo association, 1 to 3 percent slopes.

Most surveys include still other areas where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it cannot be classified by soil series. These areas are shown on the map like other mapping units, but are given descriptive names, such as Badland, Gullied land, or Mixed alluvial land, and are called land types.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. On the basis of the yield and practice tables and other data, the soil scientists set up trial groups, and then test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved re-

flect up-to-date knowledge of the soils and their behavior under present methods of use and management.

## General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the Carbon-Emery Area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The six soil associations in the Carbon-Emery Area are described in the following pages.

### 1. Chipeta-Killpack Association

*Gently rolling and gently sloping to moderately steep, well-drained, moderately fine textured soils that are shallow and moderately deep over shale; on uplands*

This soil association is made up of gently rolling and gently sloping to moderately steep soils on hills and in intermingled narrow valleys. It occupies about 6 percent of the survey area.

Chipeta soils, on the upper slopes and crests of the hills, occupy about 60 percent of the association. They are slightly to moderately saline and are slowly permeable. The Chipeta soils are underlain at a depth of 20 inches or less by shale that contains salt and gypsum. Much of their surface is bare, but scattered stands of Nuttall saltbush, mat saltbush, and shadscale provide some cover.

Gently sloping Killpack soils, on the lower parts of hills, occupy about 30 percent of the association. They are moderately fine textured and are slowly permeable. The Killpack soils are underlain by shale at a depth of 20 to 40 inches. The vegetation on these soils is largely shadscale, greasewood, galletagrass, and saltbush.

Medium-textured Ravola and moderately fine textured Billings soils occupy minor acreages in the association. Other minor acreages are occupied by very strongly saline Saltair and Cache soils. All of these soils are on alluvial fans, on flood plains, or in narrow alluvial valleys.

Most of the association is in range, but little forage is produced. The small areas that are irrigated are used for pasture and for growing alfalfa and small grains. Where the soils have been irrigated, some areas have been abandoned because a high water table has formed and salts and alkali have accumulated.

### 2. Ravola-Billings-Penoyer Association

*Nearly level to gently sloping, deep, well drained and moderately well drained, medium textured and moderately fine textured soils on alluvial fans and flood plains and in alluvial valleys*

This association consists of nearly level to gently sloping soils on alluvial fans and flood plains and in alluvial valleys between high mesas or benches. It is below the benches on the west side of much of the survey area, extending in a northeast-southwest direction. The association occupies about 30 percent of the survey area.

Ravola soils make up about 50 percent of the association. They are light brownish gray and medium textured, and they are well drained and moderately permeable.

Billings soils, generally on the lower alluvial fans, make up about 20 percent. They are also light brownish gray but are slowly permeable.

Penoyer soils, in the western part of the association, make up about 15 percent. They are on stream flood plains and alluvial fans in the mouths of canyons. Where these soils occur, fruit can be produced to a limited extent because air drainage is better and the hazard of frost damage is less than in most other parts of the survey area.

Minor acreages in the association are occupied by somewhat poorly drained Hunting soils, moderately coarse textured Green River soils, and coarse textured Beebe soils. Small patches of saline-alkali soils occupy other small acreages.

This association has the most potential for production of irrigated crops of any in the survey area. In fact, a major part of the alfalfa, corn, sugar beets, small grains, and fruit originating in the Carbon-Emery survey area is produced on these soils. The soils are moderately low in natural fertility. Where they are properly irrigated, however, response is good to applications of manure and commercial fertilizer.

### 3. Saltair-Libbings Association

*Nearly level to gently sloping, deep and moderately deep, salty, moderately fine textured soils on bottom lands and foothills*

This association occupies bottom lands and foothills near the towns of Cleveland, Castle Dale, Ferron, and Emery. The soils are mainly saline, are poorly drained, and are nearly level or gently sloping. The vegetation is saltgrass, wiregrass, sedges, and greasewood. Bare areas are common. The association occupies about 6 percent of the survey area.

Saltair soils make up about 65 percent of the association. They are moderately fine textured and have 2 percent salt within 20 inches of the surface. Bare spots are extensive and are more common where the water table is below a depth of 30 inches.

Libbings soils occupy 20 percent of the association and occur on the lower foot slopes of the shale hills that border the bottom lands. They are fine textured, are moderately deep over shale, and have 2 percent salt within 20 inches of the surface. Their profile contains distinct gypsum horizons.

Rafael soils occupy about 12 percent of the association. They are moderately fine textured, and they contain less salt and produce more vegetation than the other soils in the association.

The rest of the association is made up of minor areas of deep, fine-textured, poorly drained, salty soils.

This association is used for pasture, but the vegetation is poor in quality. The wettest areas can be pastured only in winter. Drainage and reclamation are extremely difficult and are not economically feasible.

## 4. Sanpete-Minchey Association

*Gently sloping, deep, well-drained, medium textured to moderately fine textured soils over gravel; on mesas, benches, and old alluvial fans*

This association consists mainly of isolated mesas or benches and their steep colluvial side slopes. The mesa tops are 50 to 200 feet or more above the surrounding area. The mesas are remnants of a strongly dissected alluvial fan or plain formed of alluvium that was deposited by glacial melt water. Soils on the mesas formed in this glacial outwash. The vegetation is mainly galletagrass, bud sage, winterfat, and shadscale. This association occupies about 6 percent of the survey area and lies mainly on the west side of it.

Sanpete soils occupy 57 percent of this association. They are very gravelly or cobbly, moderately coarse textured, and well drained, and they occur on the upper parts of the mesas near the plateaus.

Minchey soils make up 23 percent of the association. They are nearly level, moderately fine textured, and well drained soils that are 20 to 60 inches deep over gravel and cobblestones.

Palisade soils make up about 15 percent of the association. They are medium textured but otherwise are similar to the Minchey soils.

The rest of the association is made up of minor areas of steep Shaly colluvial land on the steep sides of mesas, and of fine-textured, strongly alkaline Harding soils that occupy a bench a few miles northeast of Emery.

Most of this association is used for grazing. Alfalfa, corn, small grains, and pasture crops are grown. These soils need large amounts of phosphorus, especially for legumes. Corn, small grains, and pasture respond to applications of nitrogen.

## 5. Chipeta-Persayo-Badland Association

*Gently sloping and gently rolling to steep, well-drained, moderately fine textured and medium textured soils that are shallow over shale, and eroding shale outcrops; on uplands*

This association is made up of gently sloping and gently rolling to steep soils on hills, and of bare areas consisting mainly of eroded shale outcrops. It occupies about 30 percent of the survey area and is mainly on the east and west sides of Castle Valley.

The Chipeta and Persayo soils together make up 80 percent of the association. The Chipeta soils are saline, moderately fine textured, and slowly permeable. They are well drained and are 10 to 20 inches deep over gypsum-bearing shale. The vegetation is a scant cover of mat saltbush and Nuttall saltbush.

The Persayo soils are medium textured and moderately fine textured, and they are moderately permeable. They are also well drained and are typically 10 to 20 inches deep over gypsum-bearing shale. The vegetation is mainly galletagrass and shadscale.

Badland makes up about 13 percent of the association. It consists of the bare areas on eroding shale outcrops.

A minor part of the association is made up of Cedar Mountain soils, Gullied land, and areas of wet alluvial land. The Cedar Mountain are fine-textured, reddish, alkali, gently rolling to steep soils on hills along the eastern edge of the survey area.

This association is used exclusively for grazing. The soils have no potential for cultivation, but they have some potential for irrigated pasture. Runoff washes large amounts of sediment from the areas of Badland and Gullied land.

## 6. Rock Land-Shaly Colluvial Land-Castle Valley-Kenilworth Association

*Gently sloping to very steep, shallow to deep, gravelly and stony soils, and rock land; on benches and hills*

This association is made up of benches and hills, dissected in places by deep ravines. Sandstone outcrops, stones, and boulders are common. The vegetation is mainly juniper, pinon, Mormon-tea, shadscale, pricklypear, squirreltail, and some sagebrush. The association comprises about 22 percent of the survey area and is mainly in the western and southwestern parts.

Rock land and Shaly colluvial land make up about 60 percent of the association. Rock land mainly consists of very steep to perpendicular sandstone and shale outcrops. Where there is soil material, the surface is more than half covered by cobblestones, other stones and boulders. Small areas are accessible to livestock and wildlife, but most of the area is too steep and rocky for grazing.

Shaly colluvial land contains fewer rock outcrops than Rock land, and the outcrops are mainly shale. Soil material is more abundant, and coarse fragments on the surface are mainly cobblestones. The slopes range from 15 to 40 percent. The only use is spring and fall range.

Castle Valley and Kenilworth soils make up about 40 percent of this association. The Castle Valley soils are medium textured and typically are less than 20 inches deep over sandstone. Sandstone outcrops are common. These soils are used for grazing, and juniper is cut for posts.

The Kenilworth soils are deep, stony, and moderately coarse textured. They are gently sloping to steep and occur on high benches, mainly below the mountains. Grazing is the main use, but in places juniper is cut for fence posts. Some areas have been cleared for seeding, but stones and inadequate amounts of rain interfere with this work.

Minor areas of the Palisade, Penoyer, Minchey, Ravola, and Sanpete soils are also in this association.

# *Use and Management of Soils*

The soils of the Carbon-Emery Area are used chiefly for irrigated crops, irrigated pasture, and range. This section discusses uses of the soils for these purposes and

gives estimated yields of the main crops. It also includes a discussion of use of the soils for wildlife and for building of roads, ponds, and other engineering works.

## Use and Management of the Soils for Crops and Pasture

Some practices are beneficial if applied to about all the soils used for irrigated crops and pasture. These are discussed here briefly to avoid repetition.

An important management requirement is the safe and uniform distribution of irrigation water. Both the border and furrow methods are suitable for hay, pasture, and small grains, and the furrow system is also suitable for row crops. Sprinklers are a suitable alternative for most crops. Losses of soil and water can be held to a minimum by using proper lengths of runs and sizes of flows in furrows and borders.

Because of the beneficial effect on soil structure, the return of organic matter is particularly important in soils that are irrigated. Sources of organic matter are crop residue, barnyard manure, and the sod crops grown in the cropping system. Practices that provide for regular additions of organic matter are ordinarily the most beneficial. The use of fertilizer in amounts sufficient to produce large increases in plant growth makes it practicable to return increased amounts of organic matter.

The low content of organic matter in soils of the survey area makes them especially susceptible to the formation of traffic pans. Good tilth can be maintained and the formation of traffic pans reduced, however, if the soils are not tilled or trampled when wet. The formation of traffic pans can also be reduced by varying the depth of tillage and limiting the number of trips over the soil with tillage equipment.

Most of the soils of this area are well supplied with potassium, calcium, iron, and magnesium. In some soils calcium carbonate is so plentiful that it interferes with absorption of iron by fruit trees and causes their leaves to turn yellow.

Soils that formed from shale in this survey area are rich in illite and kaolinite clays. These clays have a low capacity to retain plant nutrients. Thus, it is generally advantageous to make comparatively frequent applications of fertilizer to soils used for crops. Crops generally respond to a fertilizer high in content of nitrogen or phosphorus, or both, depending on the crop and the cropping history.

### *Capability groups of soils*

Capability classification is a grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have special requirements. The soils are classified according to degree and kind of permanent limitations, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest grouping, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. Classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require very careful management, or both.

Class IV soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI soils have severe limitations that generally make them unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe–2, irrigated. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* shows that the chief limitation is climate that is too cold or dry.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about the management of soils. Capability units are generally designated by adding numbers, or numbers and letters, assigned locally, for example, VIIe–D3X or Vw–2W. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter immediately following, the subclass, or kind of limitation as defined in the foregoing paragraph. The part of the symbol following the hyphen identifies the capability unit in the State system.

In the Utah system a number or letter is used to sug-

gest the chief kinds of limitation. The numbers 1 or 2 in the first position show the climate, as 1—climate with 150 to 190 frost-free days, and 2—climate with 100 to 150 frost-free days. The letters D and S in the first position are for the nonirrigated capability units and show the range of average annual rainfall. D is 4 to 8 inches, S is 8 to 12 inches. Additional numbers or letters are used to show limitations as follows.

3—inhibiting layer
4—low water holding capacity (gravelly or cobbly soils)
5—slow permeability
6—low water holding capacity (sandy soils)
7—salinity
8—alkali
X—coarse fragments on the surface
W—a beneficial water table

### *Management by capability units*

In this subsection each capability unit in the Carbon-Emery Area is described and the use and management are briefly discussed. To find the names of all the soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of this survey.

#### CAPABILITY UNIT I-1 (IRRIGATED)

This capability unit consists of loamy, deep, well-drained, nearly level soils on the flood plains of the Green River and associated alluvial fans. The soils are in the Penoyer and Ravola series.

Soils in this unit are friable and easy to work. They absorb water at the rate of 1.25 to 1.75 inches an hour. Permeability of the subsoil is moderate. These soils can hold about 11 inches of available water to a depth of 5 feet in the root zone. Of this amount, only about 5 inches of water is readily available to plants. Natural fertility ranges from low, in the Ravola soil, to moderate, in the Penoyer soils. The frost-free period is between 140 and 160 days. The average summer temperature is 76° F.

When irrigated, these soils are suitable for alfalfa, small grains, corn, sugar beets, melons, grass-legume pasture, and other crops climatically adapted. A suitable rotation consists of alfalfa or grasses and legumes grown for hay or pasture for 3 to 5 years, or for half the rotation; 2 years of corn, sugar beets, or melons; and then 2 years of a small grain before seeding back to alfalfa.

Where alfalfa is grown on a slope of 0.4 of a percent, water can be applied efficiently by the corrugation method, using runs 750 to 800 feet long. A net water application of 5 inches can be applied uniformly by a flow of 1 cubic foot per second, for a period of 7 to 8 hours, in 18 corrugations spaced 18 to 24 inches apart.

Water can also be applied efficiently by the border method, using runs 1,000 to 1,050 feet long and 50 feet wide. A net water application of 5 inches can be applied uniformly by a flow of 4 cubic feet per second per border in 1.5 to 2.0 hours.

The interval between irrigations varies with the available water-retaining capacity of the soil and the consumptive use of water by plants (*2*).[2] If these soils are at field capacity, alfalfa in July uses the 5 inches of readily available moisture in 13 to 15 days. At the end of that time, a 5-inch irrigation is needed to restore the soil to field capacity. Small grains use the most water in June. During that month, the maximum interval between irrigations is 18 to 20 days. Corn growing on these soils uses the most water in July and August. During these months, the maximum interval between irrigations is 16 to 19 days.

[2] Italic numbers in parentheses refer to Literature Cited, p. 74.

#### CAPABILITY UNIT IIe-1 (IRRIGATED)

The only soil in this capability unit is Ravola loam, extended season, 1 to 3 percent slopes. It is deep and well drained and occurs on the flood plains of the Green River and associated alluvial fans. A few areas have a surface layer of silty clay loam.

This soil is friable, easy to work, and moderately susceptible to erosion. It absorbs water at the rate of 1.25 to 1.75 inches per hour. Subsoil permeability typically is moderate, but it ranges from moderate to rapid. The soil retains about 11 inches of water in the root zone to a depth of 5 feet, but only about 5 inches is available to plants. Natural fertility is low to moderate. The frost-free season is between 140 and 160 days, and the average summer temperature is 76° F.

Where irrigated, this soil is suitable for alfalfa, small grains, corn, sugar beets, melons, grass-legume pasture, and other crops climatically adapted. A suitable rotation consists of alfalfa or grasses and legumes grown for hay or pasture for 3 to 5 years, or for half the rotation; 2 years of corn, sugar beets, or melons; and then 2 years of a small grain before seeding back to alfalfa or grasses and legumes.

Where alfalfa is grown on a slope of 1.5 percent, water can be applied with 60 percent efficiency by use of corrugations and runs 375 to 425 feet long. A net water application of 5 inches can be applied by using a flow of 1 cubic foot per second, for about 8 hours, in 60 corrugations spaced 18 to 22 inches apart.

Water can also be applied efficiently by use of the border method. Suitable runs are about 750 feet long, and borders are 40 feet wide. A net water application of 5 inches can be applied uniformly by using a flow of 1.7 cubic feet per second per border in about 1.5 hours.

The irrigation interval varies with the available water retaining capacity of the soil and the consumptive use of water by plants. If the soil in this capability unit is at field capacity, alfalfa in July uses the 5 inches of readily available moisture in 13 to 15 days. At the end of this time, the soil needs a 5-inch irrigation to restore its moisture to field capacity. Small grains use the most water in June. During that month, the irrigation interval for small grains is 18 to 20 days. Corn uses its peak amount of moisture in July and August. During this time, the interval between irrigations is 16 to 19 days.

#### CAPABILITY UNIT IIe-2 (IRRIGATED)

This capability unit consists of deep and moderately deep, well-drained, gently sloping soils on alluvial fans, flood plains, glacial outwash fans, or benches, and in narrow alluvial valleys. The soils are in the Minchey, Penoyer, Ravola, and Woodrow series.

The surface layer of these soils ranges from silty clay

loam to very fine sandy loam. The silty clay loams are fairly hard to work. Permeability ranges from slow to moderate, but dominantly it is slow. These soils absorb moisture at the rate of 0.75 to 1.25 inches per hour. They generally are low in natural fertility. In many fields, however, natural fertility is fairly high because commercial fertilizer and manure have been applied. Irrigated fields are moderately susceptible to erosion. The soils retain about 10 to 12 inches of water to a depth of 5 feet in the root zone, but only about 5 inches is readily available to plants. Summer temperatures average 66° F. The frost-free season is 120 to 140 days.

These soils are used for irrigated alfalfa, small grains (fig. 2), corn harvested for ensilage, sugar beets, and grass-legume pasture. The kinds of crops that can be grown are limited by the length of the growing season. Some orchards have been established in the mouths of canyons where the hazard of frost is reduced by good air drainage. A suitable rotation for these soils consists of alfalfa or grasses and legumes grown for hay or pasture for 4 to 6 years, or for half the rotation; 2 years of corn or sugar beets; and then 1 or 2 years of a small grain before seeding back to alfalfa.

These soils can be cultivated safely without compaction if the moisture content of the soil is 20 to 50 percent of field capacity. A seedbed is more easily prepared if the soils are plowed in fall when moist, and are allowed to remain rough over winter, than when they are plowed in spring.

*Figure 2.*—**Grain stubble and a third crop of alfalfa hay on Penoyer loam, 1 to 3 percent slopes, in capability unit IIe-2 (irrigated).**

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Land leveling to facilitate the even distribution of water can be done with little or no damage if the soils are fairly dry. If leveled when wet, the soils become very hard and compacted. The Minchey soil has a whitish limy layer 12 to 20 inches below the surface. If this layer is exposed in leveling, crop yields will be low for several years on the exposed layer.

Where alfalfa is grown on a slope of 1.5 percent, water can be applied efficiently in runs 475 to 525 feet long. A net water application of 5 inches can be applied uniformly by a flow of 1 cubic foot per second, for 10 to 12 hours, in 60 corrugations spaced 18 to 22 inches apart. The border system of irrigation generally is not used on these soils.

As a rule, the last irrigation for small grain is applied when the crop is in the milk stage. If a small grain is used as a companion crop for alfalfa or grass, a stand of pasture plants is obtained only if irrigations are timed to benefit the alfalfa or grass.

The growth of corn is sharply reduced if moisture is in short supply during the time of tasseling and silking. Corn is sensitive to over-irrigation or a high water table. Excess water causes yellowing of the leaves and stunting of growth.

The interval between irrigations varies with the available water retaining capacity of the soils and the consumptive use of water by plants. If the soils are at field capacity, alfalfa in July uses the 5 inches of readily available water in 18 to 20 days. At the end of that time, a 5-inch irrigation is needed to restore the soils to field capacity. Small grains use the most water in June. During that month, the maximum interval between irrigations is 24 days. Corn growing on these soils uses the most water in August. During that month, the maximum interval between irrigations is 22 days.

#### CAPABILITY UNIT IIe-24 (IRRIGATED)

The soils in this capability unit are deep, well drained, and gently sloping, and they occupy outwash fans or benches. They belong mainly in the Minchey and Palisade series.

All the soils in this capability unit are moderately permeable, and some are gravelly or cobbly below a depth of about 3 feet. The Minchey soils have a very pale brown layer at a depth of 12 to 20 inches, and this layer contains 30 to 50 percent lime. The Minchey and Palisade soils retain 8 to 11 inches of water to a depth of 5 feet in the root zone, but only 4.0 to 5.0 inches is readily available to plants. All the soils absorb water at the rate of 1.25 to 1.75 inches per hour. They are moderately susceptible to erosion when irrigated and are low in natural fertility. Summer temperatures average 66° F. The frost-free season is 120 to 140 days.

The soils in this capability unit are used for irrigated alfalfa, small grain, corn harvested for ensilage, and grass-legume mixtures grown for hay and pasture. The limy subsoil between 12 and 20 inches below the surface should not be exposed when these soils are leveled. Crop growth on such exposed subsoil is poor for several years.

Where alfalfa is grown on a slope of 1.5 percent, water can be applied efficiently by the corrugation method, in

runs about 400 feet long. A net application of 5 inches of water can be applied uniformly by a flow of 1 cubic foot per second in 60 corrugations spaced 18 to 22 inches apart, for a period of about 8 hours. Water can also be applied efficiently by the border method, using runs 550 to 575 feet long and 40 feet wide. A net application of 5 inches of water can be applied uniformly by using a flow of 1.7 cubic feet per second per border in about 1.5 hours.

The irrigation interval varies with the available water retaining capacity of the soil and the consumptive use of water by plants. If these soils are at field capacity, the 5 inches of readily available moisture will be used by alfalfa in July in 16 to 18 days. Five inches of water will be needed to bring these soils back to field capacity. For small grains, the maximum interval between irrigations is about 23 days during the peak use period of June. The peak use of water for corn is in August. The maximum time between irrigations during that month is about 22 days.

#### CAPABILITY UNIT IIw-1 (IRRIGATED)

The only soil in this capability unit is Green River loam. It is a deep, moderately well drained, nearly level soil on flood plains of the Green River. The surface layer is mainly loam, but in a few places it is sandy loam. The subsoil is stratified sandy loam to silt loam.

This soil is friable and easy to work, and it has moderate permeability. It absorbs water at the rate of 1.75 to 2.5 inches per hour. The soil retains 7 to 8 inches of water to a depth of 5 feet in the root zone, but only 3.5 to 4 inches is readily available to plants. The water table is 20 to 40 inches below the surface. It moves laterally, and this allows the soil to be well aerated and minimizes the effects of the high water table.

This soil has moderate natural fertility, but in many fields it has high fertility because commercial fertilizer and manure have been applied. The susceptibility to erosion is none to slight. Summer temperatures average 76° F. The frost-free season is 140 to 160 days.

This soil is used for alfalfa, small grains, corn harvested either for grain or ensilage, sugar beets, melons, grass-legume pasture, and other crops climatically adapted. A suitable crop rotation consists of alfalfa or grasses and legumes grown for hay or pasture for 3 to 5 years, or for half the rotation; 2 years of corn, sugar beets, or melons; and then 2 years of a small grain before seeding back to alfalfa.

The use of crop residue helps to reduce losses from wind erosion on this sandy soil. Soil blowing is reduced to a minimum if plowing is done in spring, and if tillage is held to a minimum before seeding.

Land leveling to facilitate even distribution of water can be done with little or no damage to this soil. Applying only enough irrigation water to satisfy the needs of the crop helps to lower the existing water table. Water applied in excess of crop requirements causes the water table to rise.

Where the water table is less than 50 inches below the surface, irrigation needs can best be determined on a field by field basis. The irrigation interval and consumptive use of water are difficult to predict for this soil because of the influence of the water table.

#### CAPABILITY UNIT IIIe-15 (IRRIGATED)

Billings silty clay loam, extended season, 1 to 3 percent slopes, is the only soil in this capability unit. It is deep, well drained, and gently sloping and occurs mainly on alluvial fans near Green River.

This soil is fairly hard to work, and it is slowly permeable. It retains about 11 inches of water to a depth of 5 feet in the root zone, but only about 5 inches is readily available to plants. Natural fertility is low, but in many fields this soil is fairly high in fertility because commercial fertilizer, manure, and other soil-building practices have been applied. The soil is moderately susceptible to erosion. Summer temperatures average 76° F. The frost-free season is 140 to 160 days.

This soil is used mainly for irrigated grass and legume pasture, alfalfa, small grains, and corn. It is fairly well suited to these crops. The seedbed is more easily prepared if plowing is done in fall when the soil is moist, and if the soil is left rough over winter, than when plowing is done in spring. Freezing and thawing break the clods. Compaction does not occur if this soil is cultivated when its content of moisture is 25 to 50 percent of field capacity.

Where alfalfa is grown on a slope of 1.5 percent, water can be applied efficiently by the corrugation system, in runs 475 to 525 feet long. A net water application of 5 inches can be applied by using a flow of 1 cubic foot per second, for about 12 hours, in 60 corrugations spaced 20 to 24 inches apart.

The interval between irrigations varies with the water retaining capacity of the soil and the consumptive use of water by plants. If the soil is at field capacity, alfalfa in July uses the 5 inches of readily available water in 13 to 15 days. At the end of that time, the soil needs a 5-inch irrigation to restore it to field capacity. Small grains have their peak period for water use in June. The maximum time between irrigation during that month is 18 to 20 days. The maximum time between irrigations for corn in July and August is 16 to 19 days.

#### CAPABILITY UNIT IIIe-2 (IRRIGATED)

In this capability unit are deep, well-drained, easily eroded, sloping soils on alluvial fans and flood plains. These soils are in the Palisade, Penoyer, and Ravola series.

The soils in this unit have a surface layer of loam or very fine sandy loam. They are friable and easy to work, and they absorb water readily. They retain 7 to 12 inches of water to a depth of 5 feet in the root zone, but only about 3.5 to 6 inches of water is readily available to plants. Permeability is moderate. All the soils, except the Penoyer, are typically low in natural fertility. The susceptibility to wind and water erosion is high. Wind erosion and sheet erosion are active, and a few shallow and a few deep gullies have formed. Summer temperatures average 66° F. The frost-free season is 120 to 140 days.

These soils are used for range and for such irrigated crops as alfalfa, small grains, and grasses and alfalfa grown for hay or pasture. A suitable crop rotation consists of growing alfalfa or grass and alfalfa for hay or pasture for 6 to 8 years, and then growing a small grain for 1 to 2 years before seeding back to grass or alfalfa.

Land shaping or smoothing to facilitate the applica-

tion of water can be done without damaging these soils. The Palisade soil has a whitish, limy layer below a depth of 8 to 12 inches. If this layer is exposed in leveling, crop growth on the area will be poor for several years.

Corrugations are commonly used and are suitable on these soils. Erosion can be reduced if water is applied in runs less than 300 feet long, and in small streams, until a sod-forming crop is established.

Head cutting and the formation of new gullies can be reduced if crops are planted at least 30 feet from existing gullies that are less than 10 feet in depth, and if waste water is channeled safely into a waterway for disposal.

#### CAPABILITY UNIT IIIe-25 (IRRIGATED)

The only soil in this capability unit is Billings silty clay loam, 1 to 3 percent slopes. It is a deep, well-drained, gently sloping soil on alluvial fans, flood plains, and colluvial slopes.

This soil absorbs water somewhat slowly, is fairly difficult to work, and is low in natural fertility. The root zone is 5 feet thick and retains 5 inches of readily available water. Permeability of the subsoil is slow. The susceptibility to erosion under irrigation is moderate. Summer temperatures average 66° F. The frost-free season is 120 to 140 days.

This soil is used for irrigated grass and legume pasture, small grains, corn harvested for ensilage, alfalfa, and sugar beets. The kinds of crops grown are limited by the short growing season. A suitable crop rotation for this soil consists of alfalfa or grass and legumes grown for hay or pasture for 4 to 6 years, or for half the rotation; 2 years of corn or sugar beets; and then 1 or 2 years of a small grain before seeding back to alfalfa.

Where alfalfa is grown on a slope of 1.5 percent, water can be applied efficiently by the corrugation method in runs about 600 feet long. A net water application of 5 inches can be applied uniformly by a flow of 1 cubic foot per second in 60 corrugations spaced 18 to 20 inches apart, in about 14 hours. The border method of irrigation generally is not used on these soils.

The interval between irrigations varies with the water retaining capacity of the soil and the consumptive use of water by plants. If the soils are at field capacity, alfalfa in July uses the 5 inches of readily available water in 18 to 20 days. At the end of that time, a 5-inch irrigation is needed to restore the soils to field capacity. Small grains use the most water in June. During that month the maximum time between irrigations is 24 days. Corn uses the most water in August. During that month the irrigation interval is 22 days.

#### CAPABILITY UNIT IIIw-2 (IRRIGATED)

The soils in this capability unit are in the Hunting series. They are deep, somewhat poorly drained, and gently sloping, and they are on flood plains and alluvial fans. The surface layer typically is loam, but in a few areas it is silty clay loam.

The Hunting soils are firm and easy to work. They absorb water at the rate of 1.25 to 1.75 inches per hour. Permeability generally is moderate, but it ranges from moderate to slow. Salinity typically is slight, but some spots are moderately saline. In most places the water table is 20 to 40 inches below the surface. These soils retain about 12 inches of water to a depth of 5 feet in the root zone, but only about 6 inches is readily available to plants. In the moderately saline areas, the amount of readily available water is about 4.5 inches. These soils are moderately susceptible to erosion if they are irrigated. Summer temperatures average 66° F. The frost-free season is 120 to 140 days.

The soils in this capability unit are suitable for irrigated grass and legume pastures, alfalfa, and small grains. Until they are reclaimed, the moderately saline spots are suitable only for grass and legume pasture.

Good control of irrigation water is needed to lower the water table and to reduce the salinity of the soils. Applying only enough irrigation water to satisfy the needs of the crop helps to lower the existing water table. Water applied in excess of crop requirements raises the water table. Linings in ditches and canals reduce losses from seepage and help to lower the water table. Land leveling to facilitate the uniform distribution of water can be done with little or no damage to the soils. The content of salt in the moderately saline areas can be reduced by a leaching irrigation applied late in fall.

The irrigation needs of these soils can best be determined by testing each field. The corrugation method is generally used. If the irrigation system is designed so that only enough water can be applied to wet the upper 36 inches of soil material, the water table is less affected. Where the water table is within 36 inches of the surface, crops usually get enough water through capillary action, except during the period of peak use in July and August. During that time, some light irrigations are needed. The yellowing of alfalfa or of other crops indicates salinity or overirrigation.

#### CAPABILITY UNIT IIIs-16 (IRRIGATED)

Only Beebe loamy fine sand, extended season, 0 to 1 percent slopes, is in this capability unit. It is a deep, well-drained, sandy soil on flood plains of the Green River. In some areas the slopes are 1 to 2 percent, and in one area they are between 3 and 6 percent. In some places the surface layer is loam 8 to 14 inches thick.

This soil is friable and easy to work. It absorbs water at the rate of 3.5 to 4.5 inches per hour. The root zone is 5 feet thick and retains 4 to 6 inches of water, but only 2 to 3 inches of water is readily available to plants. Permeability is rapid. Natural fertility is low, but enough commercial fertilizer has been applied in many fields to raise the fertility level. This soil is highly susceptible to wind erosion and water erosion. In places hummocks have formed. Summer temperatures average 76° F. The frost-free season is 140 to 160 days.

This soil is used for irrigated grass and legume pastures, cantaloups, watermelons, alfalfa, small grains, and corn harvested for grain and ensilage. A suitable rotation consists of growing alfalfa or grass for 3 to 5 years, or for half the rotation; growing corn or melons for 1 year; and then growing grain for 2 years before seeding back to alfalfa.

Where alfalfa is grown on a slope of 0.5 percent, water can be applied efficiently by the corrugation method, in runs 200 to 225 feet long. The use of runs longer than 330 feet on this soil wastes irrigation water and leaches

out plant nutrients. A net water application of 2.5 inches can be applied using a flow of 1 cubic foot per second in 18 corrugations spaced 16 to 18 inches apart, in about 2 hours.

The maximum time between irrigations in July for alfalfa to grow rapidly is 8 days. The peak use of water for grain is in June. During that month, the maximum interval between irrigations is about 11 days. If grain is used as a companion crop for alfalfa or grass, a stand of pasture plants will be obtained only if irrigations are timed to benefit the alfalfa or grass. The peak use of water by corn is in July and August, and during that period the crop needs irrigating about every 9 days. Yields of corn are sharply reduced if moisture is short in supply during the tasseling and silking stages. A shortage of moisture after the hard-dough stage has been reached does not affect corn yields. To maintain good growth of plants, pastures should be irrigated every 7 days.

### CAPABILITY UNIT IVe-25 (IRRIGATED)

The soils in this capability unit are in the Killpack series. They are 20 to 40 inches deep over shale bedrock, are well drained, and occur on the side slopes of shale hills. These soils are gently to moderately sloping. The surface layer is clay loam or silty clay loam to loam.

These soils generally are hard to work, but the areas of loam are somewhat easier to work than the areas of clay loam. These soils absorb water at the rate of 0.4 to 0.75 inch per hour. Permeability typically is slow, but it is moderate to slow in areas that have a loam surface layer. The soils generally retain 6 to 8 inches of water in the 3- to 4-foot depth of the root zone, but only 3.5 to 4.5 inches is readily available to plants. Natural fertility is low. Salinity ranges from slight to moderate. The susceptibility to erosion is moderate under irrigation. Summer temperatures average 66° F. The frost-free season is 120 to 140 days.

These soils are used for irrigated grass and legume pastures, small grains, and alfalfa. A suitable crop rotation consists of 6 to 8 years of alfalfa or grass and alfalfa grown for hay or pasture, followed by 1 to 2 years of a small grain before seeding back to alfalfa.

The seedbed is more easily prepared if plowing is done in fall when the soil is moist, and if the soil is left rough over winter, than when plowing is done in spring. The soils can be cultivated without compaction if the moisture content is 25 to 50 percent of field capacity.

Careful application of water is needed. Any water applied in excess of field capacity moves downslope on the nearly impervious underlying shale, and it comes to the surface in the level areas below and causes them to be poorly drained. The water then evaporates, and the soils become salty.

Land leveling to facilitate even distribution of irrigation water can damage these soils if the shale is exposed. In addition, these soils become very hard and compacted if they are leveled when wet.

Where alfalfa is grown on a slope of 1.5 percent, water can be applied efficiently by the corrugation method, using runs 550 to 575 feet long. A net water application of 4 inches can be applied by using a flow of 1 cubic foot per second in 60 corrugations spaced 20 to 24 inches apart, in about 14 hours.

Alfalfa and pasture plants have their peak use of water during July. In that month the maximum interval between irrigations is about 16 days. Small grains have their peak use of water in June. During that month, the maximum interval between irrigations is about 19 days.

### CAPABILITY UNIT IVs-24 (IRRIGATED)

This capability unit consists of gently sloping, well-drained soils that contain gravelly or cobbly material and are on benches or mesas. These soils are mainly in the Sanpete series. The surface layer is gravelly sandy clay loam. At depths below 14 to 20 inches, the texture ranges from sandy loam to loamy sand, and from 50 to 80 percent of the soil material is cobblestones and gravel.

These soils are rapidly permeable, and they absorb water at the rate of 3.5 to 4.5 inches per hour. They retain about 3.5 inches of water to a depth of about 5 feet in the root zone, but only about 2 inches is readily available to plants. These soils are moderately susceptible to erosion. The loss of small amounts of surface soil is serious because the surface layer already is thin. The frost-free period is between 120 and 140 days. The average temperature in summer is 66° F.

The soils in this capability unit are used for range and for irrigated alfalfa, small grains, and grass-legume pastures. A few orchards have also been established near the mouths of canyons where air drainage is good. A suitable crop rotation is one in which alfalfa or grasses and legumes are grown for hay or pasture most of the time. This rotation can be varied by growing a small grain for 1 to 2 years and then seeding back to alfalfa or pasture and using the small grain as a companion crop. A commercial fertilizer is needed in addition to manure and crop residue.

These soils are too gravelly for land leveling, but land smoothing is of value in obtaining uniform applications of water. Lining ditches or canals is desirable to prevent losses from seepage in these porous, gravelly soils.

These soils are usually irrigated by use of a corrugation system. The maximum interval between irrigations in July is about 8 to 10 days for pasture or alfalfa.

### CAPABILITY UNIT IVs-26 (IRRIGATED)

This capability unit consists of deep, well-drained, sandy, gently sloping to moderately sloping soils on alluvial fans and flood plains. These soils are in the Beebe series. Their surface layer is mainly loamy fine sand, but in some areas it is loam.

These soils are very friable and are easy to work. They absorb water at the rate of 3.5 to 4.5 inches per hour. Natural fertility is low, and permeability is rapid to moderately rapid. The soils retain 4 to 6 inches of water in 5 feet of the root zone, but only 2 to 3 inches is readily available to plants. In the uncultivated areas, the soils are strongly affected by alkali, but this is readily leached out by irrigation water. The susceptibility to wind erosion and water erosion is high, and in some areas shallow gullies have formed. Summer temperatures average 66° F. The frost-free season is 120 to 140 days.

These soils are used for range and for such irrigated crops as alfalfa, small grains, corn, and mixtures of grass and alfalfa grown for hay or pasture. A suitable crop rotation consists of alfalfa or grass and alfalfa

grown for hay or pasture for 4 to 6 years; 1 year of corn; and then 1 year of a small grain before seeding back to alfalfa.

These soils are generally leveled or smoothed so that water can be applied evenly. Where alfalfa is grown on a slope of 1.5 percent, water can be applied satisfactorily by the corrugation method, in runs 125 feet long. A net water application of 2.5 inches can be applied by using a flow of 1 cubic foot per second, for 1.5 to 2.0 hours, in about 60 corrugations spaced 18 inches apart.

The interval between irrigations varies with the available water capacity of the soil and the consumptive use of water by plants. Alfalfa in July uses 3 inches of readily available water in about 10 days. At the end of that time, a 3-inch irrigation is needed to restore the soils to field capacity. The peak use of water by grain is in June. During that month, the maximum interval between irrigations is about 12 days. Grass and alfalfa pastures should be irrigated at intervals of 7 to 10 days to maintain rapid growth of plants.

#### CAPABILITY UNIT IVs-28 (IRRIGATED)

This capability unit consists of deep, moderately well drained and somewhat poorly drained, gently sloping soils on alluvial fans and flood plains. The surface layer is loam or silty clay loam. The soils are in the Billings, Hunting, and Penoyer series.

These soils are fairly hard to work. The Hunting soil is moderately permeable below a depth of about 14 inches, and the Billings is slowly permeable. The water table generally is between 30 and 40 inches from the surface, and mottles are between 20 and 40 inches. Salinity typically is moderate, but it ranges from slight to strong. The soils absorb about 0.75 to 1.25 inches of water per hour. They retain about 12 inches of water to a depth of 5 feet in the root zone, but only about 4.5 inches is readily available to plants. Salts reduce the amount of readily available water. The susceptibility to erosion is moderate. The average temperature in summer is 66° F. In most places the frost-free season is 120 to 140 days, but it is more than 150 days near Green River.

These soils are better suited to barley or improved irrigated pasture than to other uses unless they are drained and reclaimed. They can be cultivated without compaction if the moisture content is 20 to 50 percent of field capacity. The seedbed is more easily prepared if the soils are plowed in fall and are left rough over winter than when plowing is done in spring. Little or no compaction occurs if the soils are leveled when fairly dry. Livestock should not graze the pasture when the soils are wet.

Good control of irrigation water is needed to reduce salinity and the effects of a high water table. Applying only enough water to satisfy the needs of the crop prevents a rise in the water table, but any water applied in excess of crop needs causes the water table to rise. Linings in ditches and canals reduce seepage and help to lower the water table. The content of salt can be reduced by giving the soils a leaching irrigation late in fall.

The irrigation needs of these soils can best be determined by testing each field. The corrugation method is generally used. Applications of water that wet only the upper 3 feet of soil add little water to the water table. Where the water table is within 36 inches of the surface, crops usually get enough water through capillary action, except during the peak period of use in July and August. During those months, some light irrigations are needed. The yellowing of leaves, especially of alfalfa and clover, indicates that the crop has been overirrigated.

#### CAPABILITY UNIT Vw-2W (NONIRRIGATED)

This capability unit consists of deep and moderately deep, poorly drained or somewhat poorly drained, nearly level and gently sloping soils on alluvial fans and flood plains. The texture of the surface layer ranges from loam to silty clay loam. These soils are in the Ferron and Palisade series.

Permeability ranges from moderate to slow. In most places salinity is moderate, but in some places it is none to slight. The water table typically is within 20 to 30 inches of the surface, but it is lower in some seasons of the year.

These soils are suited to pasture and meadow hay and are used for those purposes. They can be reseeded, fertilized, and given other management to increase the production of forage.

#### CAPABILITY UNIT VIe-23 (IRRIGATED)

This capability unit consists of well-drained, eroded soils that are shallow and moderately deep over shale. The surface layer is loam to silty clay loam. These soils are on the side slopes of rolling clay hills. They are in the Chipeta, Persayo, and Killpack series.

These soils are generally hard to work, and they absorb moisture slowly. Permeability typically is slow. Natural fertility is low, and salinity ranges from slight to moderate. The soils retain 3 to 6 inches of water, the amount depending on the depth to shale, but only 2 to 3 inches is readily available to plants. The susceptibility to erosion ranges from moderate, in the Chipeta and Persayo soils, to high, in the Killpack soils. Gullies 3 to 6 feet deep and 100 to 300 feet apart are in the areas of Killpack soils. The frost-free season is 120 to 140 days.

The soils in this capability unit are used for range and irrigated crops. They are well suited to mixtures of grasses and legumes grown for pasture in rotation with a small grain grown to renew the stand of grass. The corrugation method is generally used when irrigating these soils. Lengths of runs and sizes of flows are variable and depend on the crop and on the slope of the field. For alfalfa and pasture, the interval between irrigations is 9 to 12 days.

Head cutting and the formation of new gullies can be reduced if crops are planted at least 30 feet from existing gullies that are less than 10 feet deep, and if waste water is channeled to safe waterways for disposal.

#### CAPABILITY UNIT VIw-2 (NONIRRIGATED)

This capability unit consists mainly of recently deposited alluvial soil material that is stratified and variable in texture and is called Mixed alluvial land. In addition, it includes soils of the Abbott and Killpack series. The Abbott soil is mainly along streams, and in places it is subject to stream overflow and to a fluctuating water table. The Killpack soil is moderately deep over shale. In many places below settlements, the surface layer is moderately to strongly saline.

These soils are used mainly for pasture. A small acreage is suitable for crops or improved pasture.

#### CAPABILITY UNIT VIIe-D (NONIRRIGATED)

This capability unit consists of well-drained, nearly level to sloping, eroded soils and of some soils that are moderately deep over shale. The surface layer is silty clay loam to loam. The soils are on alluvial fans and flood plains and in narrow alluvial valleys. They are in the Billings, Killpack, Penoyer, Ravola, and Bunderson series. Some irregularly shaped slickspots consisting of Bunderson loam are within areas of Ravola soils.

The soils of this unit retain from 5.5 to 11 inches of moisture. They are seldom moistened to a depth of 3 feet by precipitation. Fertility and the content of organic matter are naturally low.

These soils are moderately to highly susceptible to erosion. Gullies are 3 to 10 feet deep and about 100 to 500 feet apart. Without irrigation, these soils are suited only to range. Reseeding of grasses, clearing of brush, or other practices are not feasible, because of the limited amount of precipitation.

#### CAPABILITY UNIT VIIe-D3 (NONIRRIGATED)

In this capability unit are the Chipeta soils that are intermingled with and were mapped with areas of Badland and with Persayo soils. These Chipeta soils are rolling to steep and are less than 20 inches deep over shale bedrock. The surface layer is silty clay loam. Shale outcrops are common, and in places they cover 20 percent of the surface.

These Chipeta soils are slowly permeable and have a slow rate of infiltration. They are moderately eroded and are highly susceptible to further erosion. Rills and gullies are common. The soils retain 2 to 3 inches of water that is available to plants, but they are usually dry because of the limited rainfall. Salinity is moderate.

These soils are used only for range and are suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIe-D3X (NONIRRIGATED)

The only soil in this capability unit is Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded. It is shallow and well drained, and it is less than 20 inches deep over shale.

This soil typically is affected by alkali, and it is low in organic matter and fertility. Permeability and infiltration are slow. The susceptibility to further erosion is slight to high. Sheet erosion is active, and shallow gullies have formed in most areas. The soil retains about 3 inches of water, but it is usually dry because of the limited rainfall.

This soil is used for range and is suited to that purpose. Such practices as reseeding of grasses and clearing of brush to improve the range are not feasible, because of the limited rainfall.

#### CAPABILITY UNIT VIIe-D4 (NONIRRIGATED)

In this capability unit are the Persayo soils that are intermingled with Chipeta soils and were mapped with those soils. These Persayo soils are generally less than 20 inches deep over shale bedrock, but in some places they are deeper than 20 inches.

The Persayo soils have a loam surface layer. They are slowly permeable and are highly susceptible to further erosion. Most areas are eroded. In some places gullies 3 to 6 feet deep and 100 to 300 feet apart have cut through the underlying shale. These soils retain about 2.5 inches of water that is available to plants, but they are usually dry because of the limited rainfall. Salinity ranges from slight to moderate.

These soils are used only for range and are suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIe-D6 (NONIRRIGATED)

This capability unit consists of sandy, deep, well-drained, gently to moderately sloping soils of the Beebe and Penoyer series. These soils are on alluvial fans and flood plains and in narrow valleys. The surface layer is very fine sandy loam, loam, and loamy fine sand. Some of the soils are eroded and contain shallow gullies and rills.

These soils hold 4.0 to 7.5 inches of water available to plants. Runoff is slow to medium, and permeability is moderate. The susceptibility to erosion is moderate to high. The frost-free season is 110 to 160 days.

The soils are used for range.

#### CAPABILITY UNIT VIIe-S (NONIRRIGATED)

The only soil in this capability unit is Palisade very fine sandy loam, 3 to 6 percent slopes, eroded. It is on benches and mesas and is deep and well drained.

This soil is moderately to rapidly permeable. It retains 8 to 9 inches of water, but it is usually dry because of the limited rainfall. The susceptibility to sheet erosion is moderate. Gullies have formed in some places.

This soil is used for range and is suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIe-S4 (NONIRRIGATED)

The soils in this capability unit are loams or sandy clay loams underlain by gravelly or cobbly material that is high in lime. Generally, they are not alkali affected. These soils are on benches and mesas. They are in the Minchey series.

These soils are rapidly to slowly permeable. They can retain 5 to 6 inches of water but are usually dry because of the limited rainfall. Water seldom penetrates more than 24 inches. Fertility is low. The susceptibility to erosion is moderate.

These soils are used for range and are suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIw-28 (NONIRRIGATED)

This capability unit consists of deep and moderately deep, nearly level and gently sloping, poorly drained, strongly saline and alkali soils on alluvial fans and flood plains. The surface layer is silty clay loam. These

soils are in the Abbott, Libbings, Saltair, and Rafael series.

Permeability typically is slow. Platy crusts of salt on the surface, underlain by layers of soft, granular material, are common. The water table generally is 30 to 60 inches beneath the surface, but it may be within 20 inches of the surface early in summer.

These soils are used for and are suited to range. Because they are strongly saline, they are not suitable for reseeding or other practices intended to increase the production of forage. The dominant vegetation is greasewood and saltgrass.

#### CAPABILITY UNIT VIIs-D (NONIRRIGATED)

In this capability unit are deep, well-drained, nearly level silty clay loams and clay loams on alluvial fans and flood plains and in narrow alluvial valleys. Some areas are moderately deep over shale. The soils are in the Billings, Killpack, Penoyer, Ravola, and Woodrow series.

Permeability is slow, and fertility and the content of organic matter are low. The soils retain 5.5 to 11 inches of water. The susceptibility to erosion is slight to moderate.

Unless these soils are irrigated, they are suited only to range. Reseeding, clearing of brush, and similar practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIs-DX (NONIRRIGATED)

This capability unit is composed of the miscellaneous land type called Shaly colluvial land. This land type consists of a mixture of soil material, cobblestones, and stones that have accumulated on strong to steep slopes. In places shale bedrock crops out, but in other places the soil material is as much as 3 feet thick over shale.

The susceptibility to erosion is moderate to high. The capacity to retain moisture is variable and depends on the thickness and kind of material over shale bedrock. Because of the limited amount of precipitation, this land type usually is dry.

This land type is suitable for range. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIs-S3 (NONIRRIGATED)

The only soil in this capability unit is Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded. It consists of medium-textured to coarse-textured material that typically is less than 20 inches deep over sandstone bedrock.

Permeability is moderate to rapid. The susceptibility to erosion is slight to high. This soil retains 3 to 4 inches of water but is generally dry because of the limited amount of rainfall.

This soil is used for range and is suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIs-S4 (NONIRRIGATED)

This capability unit consists of well-drained, gently to strongly sloping soils of the Harding and Sanpete series. These soils are on mesas and benches.

The soils retain from 3.5 to 5.5 inches of water available to plants, depending on the texture of the subsoil. Runoff is medium to rapid, and the susceptibility to erosion is moderate to high. Permeability is slow in the Harding soil and rapid in the Sanpete soils. The frost-free season is 110 to 130 days.

These soils are used for range. Inadequate amounts of rain limit the success of range seeding.

#### CAPABILITY UNIT VIIs-SX (NONIRRIGATED)

In this capability unit are deep, gently sloping to steep areas of Stony alluvial land and of Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded. These soils are near very steep mountains. They occupy the slopes of benches or mesas or are on recently formed flood plains of streams.

Permeability is moderate to rapid, and natural fertility is moderate to low. The susceptibility to sheet erosion is moderate; some gullies have formed. The soils retain about 4 inches of water but are dry most of the time.

These soils are used for range and are suited to that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIc-D (NONIRRIGATED)

This capability unit consists of deep and moderately deep, nearly level to sloping, well-drained loams and very fine sandy loams. The soils are on alluvial fans, on flood plains, and in narrow alluvial valleys. They are in the Penoyer, Ravola, and Killpack series.

Permeability is moderate. The susceptibility to erosion is slight to moderate. The soils can retain 5 to 11 inches of water. The content of organic matter is low. Natural fertility of the Ravola and Killpack soils is low; that of the Penoyer soils is moderate.

Unless these soils are irrigated, they are suitable only for range. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIc-S (NONIRRIGATED)

This capability unit consists of deep, well-drained, nearly level very fine sandy loams, loams, and sandy clay loams, on mesas and benches. These soils are in the Minchey and Palisade series.

These soils are moderately to readily permeable. As a rule, they can retain 8 to 9 inches of water. All the soils usually are dry because of the limited amount of rainfall. The susceptibility to sheet erosion is moderate; gullies have formed in some areas.

Unless these soils are irrigated, they are suited only to range, and they are used for that purpose. Reseeding of grasses and clearing of brush or other mechanical practices that would improve the range are not feasible.

#### CAPABILITY UNIT VIIIe-2 (NONIRRIGATED)

This capability unit consists only of Gullied land. This land type is the source of the high content of silt in runoff, and it has little potential for the production of vegetation. Small areas are used for grazing, but the main use of this land type is for wildlife habitat.

CAPABILITY UNIT VIIIw-4 (NONIRRIGATED)

This capability unit consists of the land type Riverwash, which is gravelly and cobbly. Areas of this land type are subject to damaging overflows and do not support the growth of plants. Their main use is for wildlife habitat.

CAPABILITY UNIT VIIIw-8 (NONIRRIGATED)

This capability unit consists of deep, poorly drained, very strongly saline, fine textured and moderately fine textured soils that generally have a crust of salt ½ to 1 inch thick on the surface. These soils are in the Cache, Libbings, and Saltair series.

Because of their high content of salt, these soils have no known farm use. Plants cannot grow on them. Experience indicates that reclaiming these soils for use as salt meadow pasture is economically not feasible.

CAPABILITY UNIT VIIIs-3 (NONIRRIGATED)

This capability unit consists only of bare, steep ledges of Rock land on which plants do not grow. The only use is for wildlife habitat, water supply, and esthetic purposes.

CAPABILITY UNIT VIIIs-7 (NONIRRIGATED)

This capability unit consists of rough, broken, and nearly bare areas of Badland and of a Bunderson soil. These areas have little potential for the production of plants and are sources of silt carried by runoff.

Small areas are used for a limited amount of grazing. The areas are used mainly, however, as a habitat for wildlife, for water supply, and for esthetic purposes.

### *Estimated yields*

Table 1 gives the estimated average acre yields of the principal crops and pasture grown on irrigated soils under two levels of management. These yields are estimated on the basis of records obtained from farmers for the specific soils, on field observations of soil scientists, and on data compiled by economists of the Colorado River Storage Project. If no information was available for a particular soil, the estimates were made on the basis of yields on a similar soil. Only soils that are suitable for the crops and pasture specified are listed in table 1. In a given year, yields may be considerably higher or lower than the estimated average.

Under both levels of management, yields are based on a generalized crop rotation consisting of 5 years of a legume, 2 years of row crops, and 2 years of small grain. This rotation or a variation of it is used in most of the survey area. The kinds of row crops to be grown depend on the expected supply of irrigation water. Oats or barley normally are grown as a nurse crop to new seedings of alfalfa.

The yields in columns A are those that can be expected under average, or common, management. Under common management, phosphorus fertilizer is applied sparingly or not at all; nitrogen is seldom used. Most of the available animal manure is spread. Sugar beets generally are fertilized with phosphorus and nitrogen.

Under common management, water-control structures generally are inadequate, and water is applied without enough regard to proper length of run or to the timely needs of crops. Pastures are not clipped; rotation grazing is not practiced, and no commercial fertilizer is applied. In some instances droppings are scattered, but generally they are not.

The yields in columns B are those expected over a period of years under a moderately high level of management. This management provides that phosphorus fertilizer is applied when new seedings of alfalfa are being established and again after 2 or 3 years. Nitrogen fertilizer is used on row crops after the first year out of alfalfa and occasionally on small grains, unless animal manure is available. All available animal manure is spread. Tillage is reduced to essential, timely operations to avoid traffic pans or compacting the soil. In addition, operators use control structures for handling irrigation water, use proper lengths of runs that are adapted to soil conditions, and apply water in the quantity that satisfies crop requirements.

Under a moderately high level of management, irrigated pastures generally contain about 50 percent alfalfa and 50 percent grass. Regardless of the amount of alfalfa, fewer animals die of bloat when rotation grazing is used than when it is not used. Alfalfa is allowed to mature to the hay stage before animals graze it, and then animals are concentrated so that all the forage is consumed within a few days.

Pastures that are rotated, and in which alfalfa is the primary source of forage, should be grazed about 6 days and then rested for 28 to 40 days to allow for the regrowth of plants. The length of the regrowth period is about the same as the interval between hay cuttings. Six paddocks, or grazing units, generally are well suited to rotation grazing. This is the minimum number of paddocks that can be used if irrigation water is applied about every 14 days. This number allows for an irrigation immediately after grazing is finished and again 6 to 7 days before the next grazing so that the soil is dry when grazed.

At the stocking rate of 20 cows per acre, 6 days are needed to harvest efficiently the forage in a 5-acre pasture. Pastures grazed at this rate seldom need to be mowed for weed control oftener than every other year. Droppings are spread each year.

From 40 to 50 pounds of available nitrogen fertilizer are applied before growth starts each spring. Phosphorus fertilizer is applied every 2 or 3 years.

The length and warmth of the growing season at Green River allows farmers to have a greater variety of crops and larger yields than are feasible in the other parts of the survey area. For this reason, the soils at Green River are designated "extended season" phases to separate them from their counterparts in Castle Valley. For example, at Green River three full crops of alfalfa are obtained, and corn matures and is harvested for grain. In Castle Valley, on the other hand, alfalfa produces only two full crops and part of a third, and corn does not mature for grain. The frost-free period in Green River is 140 to 160 days, and the average temperature in summer is 76° F. In Castle Valley, the frost-free season is 110 to 130 days, and the average temperature in summer is 66° F.

The amount of soluble salts or alkali in the soil determines the kinds of crops that can be grown, and it affects crop yields.

TABLE 1.—*Estimated average acre yields of principal crops and pasture on irrigated soils*

[Yields in columns A are to be expected under common management; yields in columns B are to be expected under a moderately high level of management. Absence of yield indicates crop is seldom grown on the soil specified]

| Soil | Alfalfa | | Corn (grain) | | Corn (ensilage) | | Wheat | | Barley | | Oats | | Irrigated pasture | | Sugar beets | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | A | B | A | B | A | B | A | B |
| | *Tons* | *Tons* | *Bu.* | *Bu.* | *Tons* | *Tons* | *Bu.* | *Bu.* | *Bu.* | *Bu.* | *Bu.* | *Bu.* | *Cow-acre-days* [1] | *Cow-acre-days* [1] | *Tons* | *Tons* |
| Beebe loam, 1 to 3 percent slopes | 3 | 4.5 | ---- | ---- | 13 | 18 | 35 | 45 | 45 | 60 | 50 | 60 | 150 | 250 | 17 | 23 |
| Beebe loamy fine sand, 1 to 3 percent slopes | 3 | 4 | ---- | ---- | 10 | 15 | 25 | 40 | 40 | 50 | 40 | 50 | 150 | 210 | 16 | 22 |
| Beebe loamy fine sand, 3 to 6 percent slopes, eroded | 2 | 3 | ---- | ---- | ---- | ---- | ---- | ---- | 30 | 40 | 30 | 45 | 130 | 180 | ---- | ---- |
| Beebe loamy fine sand, extended season, 0 to 1 percent slopes [2] | 3 | 5 | 50 | 75 | 10 | 15 | ---- | ---- | 40 | 60 | 40 | 60 | 200 | 280 | 18 | 24 |
| Billings silty clay loam, 1 to 3 percent slopes | 2.5 | 4 | ---- | ---- | 12 | 18 | 35 | 45 | 45 | 70 | 50 | 70 | 150 | 210 | 16 | 22 |
| Billings silty clay loam, deep watertable, 1 to 3 percent slopes | 2 | 3 | | | ---- | ---- | ---- | ---- | 30 | 50 | 25 | 50 | 140 | 200 | ---- | ---- |
| Billings silty clay loam, extended season, 1 to 3 percent slopes [3] | 3 | 5 | 55 | 80 | 12 | 17 | ---- | ---- | 50 | 60 | 50 | 60 | 250 | 280 | 19 | 26 |
| Chipeta-Persayo association, 1 to 3 percent slopes | 1.5 | 2.5 | ---- | ---- | ---- | ---- | 13 | 25 | 20 | 40 | 20 | 50 | 60 | 100 | ---- | ---- |
| Green River loam [4] | 4 | 5 | 75 | 100 | 12 | 18 | ---- | ---- | 55 | 70 | 55 | 70 | 250 | 320 | 20 | 26 |
| Hunting loam | 3 | 4 | ---- | ---- | 10 | 15 | 30 | 40 | 40 | 60 | 40 | 60 | 180 | 240 | 16 | 22 |
| Hunting loam, moderately saline | 1.5 | 3 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 100 | 180 | ---- | ---- |
| Hunting silty clay loam | 3 | 4 | ---- | ---- | 10 | 15 | 30 | 40 | 40 | 60 | 40 | 60 | 180 | 240 | 16 | 22 |
| Killpack clay loam, 1 to 3 percent slopes | 2 | 3.5 | ---- | ---- | 10 | 15 | 20 | 30 | 30 | 40 | 30 | 40 | 140 | 200 | ---- | ---- |
| Killpack clay loam, 3 to 6 percent slopes, eroded | 2 | 2.5 | ---- | ---- | ---- | ---- | ---- | ---- | 20 | 40 | 20 | 40 | 90 | 150 | ---- | ---- |
| Killpack loam, 1 to 3 percent slopes | 2.5 | 4 | ---- | ---- | 9 | 15 | ---- | ---- | 40 | 50 | 40 | 50 | 180 | 240 | ---- | -- |
| Killpack loam, 3 to 6 percent slopes, eroded | 2.5 | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 120 | 180 | ---- | ---- |
| Minchey clay loam, 1 to 3 percent slopes | 3 | 4 | ---- | ---- | 12 | 18 | 30 | 40 | 35 | 50 | 35 | 50 | 150 | 250 | ---- | ---- |
| Minchey loam, 1 to 3 percent slopes | 3 | 4 | ---- | ---- | 12 | 18 | 30 | 40 | 35 | 50 | 35 | 50 | 150 | 250 | --- | ---- |
| Palisade very fine sandy loam, 1 to 3 percent slopes | 3 | 4 | ---- | ---- | 12 | 18 | 30 | 40 | 50 | 70 | 50 | 70 | 160 | 250 | ---- | ---- |
| Palisade very fine sandy loam, 3 to 6 percent slopes, eroded | 2.5 | 3.5 | ---- | ---- | ---- | ---- | ---- | ---- | 35 | 50 | 35 | 50 | 120 | 200 | ---- | ---- |
| Penoyer loam, 1 to 3 percent slopes | 4 | 5 | ---- | ---- | 15 | 22 | 35 | 50 | 45 | 75 | 45 | 75 | 210 | 260 | 18 | 24 |
| Penoyer loam, 3 to 6 percent slopes, eroded | 3 | 5 | ---- | ---- | ---- | ---- | ---- | ---- | 35 | 65 | 40 | 65 | 160 | 220 | ---- | --- |
| Penoyer loam, extended season, 0 to 1 percent slopes [4] | 5 | 6 | 80 | 100 | 15 | 22 | ---- | ---- | 60 | 75 | 60 | 75 | 250 | 320 | 20 | 26 |
| Penoyer silty clay loam, 1 to 3 percent slopes | 4 | 5 | ---- | ---- | 15 | 22 | 35 | 50 | 45 | 75 | 45 | 75 | 180 | 260 | 17 | 23 |
| Penoyer silty clay loam, extended season, 0 to 1 percent slopes [4] | 4 | 5 | 80 | 100 | 15 | 20 | ---- | ---- | 60 | 75 | 60 | 75 | 280 | 360 | 19 | 26 |
| Penoyer very fine sandy loam, 1 to 3 percent slopes | 3 | 4 | ---- | ---- | 13 | 20 | 35 | 50 | 40 | 55 | 40 | 60 | 180 | 225 | ---- | ---- |
| Penoyer very fine sandy loam, 3 to 6 percent slopes, eroded | 2 | 3 | ---- | ---- | ---- | ---- | ---- | ---- | 30 | 40 | 30 | 45 | 150 | 200 | ---- | ---- |
| Ravola loam, 1 to 3 percent slopes | 3 | 4.5 | ---- | ---- | 13 | 18 | 35 | 50 | 45 | 61 | 45 | 68 | 210 | 260 | 18 | 24 |
| Ravola loam, 1 to 3 percent slopes, eroded | 3 | 4 | ---- | ---- | 10 | 15 | 30 | 40 | 40 | 55 | 42 | 54 | 200 | 240 | ---- | ---- |
| Ravola loam, 3 to 6 percent slopes, eroded | 3 | 4 | ---- | ---- | ---- | ---- | 25 | 40 | 40 | 55 | 42 | 54 | 150 | 200 | ---- | ---- |
| Ravola loam, extended season, 0 to 1 percent slopes [4] | 5 | 6 | 80 | 100 | 15 | 20 | ---- | ---- | 60 | 75 | 60 | 75 | 280 | 360 | 20 | 28 |
| Ravola loam, extended season, 1 to 3 percent slopes [4] | 5 | 6 | 80 | 100 | 15 | 20 | ---- | ---- | 60 | 75 | 60 | 75 | 280 | 360 | 20 | 28 |
| Ravola silty clay loam, 1 to 3 percent slopes | 3 | 4 | ---- | ---- | 10 | 15 | 30 | 40 | 40 | 55 | 42 | 54 | 200 | 240 | ---- | ---- |
| Sanpete sandy clay loam, 1 to 3 percent slopes | 1.5 | 3 | ---- | ---- | 6 | 10 | ---- | ---- | 30 | 40 | 30 | 40 | 100 | 150 | ---- | ---- |
| Sanpete sandy clay loam, 3 to 10 percent slopes, eroded | 1 | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 70 | 120 | ---- | ---- |
| Woodrow silty clay loam | 2.5 | 4 | ---- | ---- | 13 | 20 | 30 | 40 | 50 | 70 | 50 | 60 | 160 | 250 | 16 | 22 |

[1] Cow-acre-days is a term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture is grazed during a single season without injury to the sod. An acre of pasture that provides 30 days of grazing for 2 cows has a carrying capacity of 60 cow-acre-days.

[2] Yields under common management and under moderately high level management for cantaloups are 10 tons and 15 tons, respectively; for watermelons they are 15 tons and 20 tons, respectively.

[3] Yields under common management and under a moderately high level of management for cantaloups are 12 tons and 18 tons, respectively.

[4] Yields under common management and under a moderately high level of management for cantaloups are 8 tons and 10 tons, respectively; for watermelons they are 10 tons and 15 tons, respectively.

## Use and Management of the Soils for Range[3]

This part gives information about livestock operations in the survey area. It also describes the grouping of soils in range sites and the management of range sites. Some soils were not placed in a range site, because they are not suitable for range or they are used only for crops or tame pasture.

Both cattle and sheep graze the rangelands of the survey area. Most of the range is better suited to winter use than to use in other seasons, but some of it is grazed year long. Grazing has no set patterns. Many livestock owners have permits to graze small numbers of sheep or cattle on the Manti-LaSal National Forest in summer. In September livestock are brought from summer range to graze crop aftermath in irrigated fields. In November operators who have the privilege of grazing livestock on the public domain move their animals to winter range on the east side of the valley.

In years of drought, cattle generally are returned to the farms in January and then are fed hay and concentrates. As soon as the range plants green up in spring, these cattle are turned out to graze on adjacent rangeland. Rangeland near irrigated farmland generally is in poor condition because livestock come to the irrigation ditches or canals for water. The forage around watering places is heavily grazed and usually is grazed at a critical growth period.

Seventy-five percent of the livestock producers in the survey area own less than 50 head of cattle. The producers who own the largest number of cattle have less than 150 to 200 head. Most of those who own sheep have 600 head or less. To reduce the expense of herding, owners join their herds when grazing on National Forest or other public land. About three-fourths of the ranchers supplement their income from livestock by working in local coal mines or for county and State Governments.

When the first livestock producers brought cattle into the survey area, they found lush forage along the river bottoms and adequate grazing on the benches to support a livestock industry. Water was diverted from streams and applied on the soils that were best suited to cultivation. The numbers of livestock increased as the population increased. All livestock depended on the open ranges for most of their forage.

In a few years native plants showed signs of grazing pressure. Many of the most palatable plants weakened, did not produce much forage even in years of adequate moisture, and eventually died. They were replaced by less palatable plants, which died under continued grazing pressure, and were replaced by plants of little or no value for grazing.

### *Range sites and condition classes*

To manage his range well and to use the range to best advantage, the rancher should know the different kinds of soil in his holdings, the location of each kind of soil, and the kinds and amounts of vegetation that can be grown on each. He can then regulate grazing so that the vigor and abundance of the best plants are increased.

The basic unit on which management of the range is determined is the range site. A range site is an area of range uniform enough in climate, soils, drainage, exposure, and topography that it produces a specific kind and amount of vegetation. The kind of vegetation, in most instances, is the combination of plants that grew on the site before the range was affected by grazing or cultivation and is called the potential vegetation. Generally, the potential vegetation is the most productive combination of range plants that a site can support. The potential vegetation, or plant community, remains on the site if it is not disturbed by fire, excessive grazing, insects, or plant diseases.

If the range is grazed heavily or at the wrong time, the most valuable forage plants on the range, called *decreasers*, become more scarce and eventually disappear. Their place is taken by *increasers*, or less palatable plants that made up only a small part of the original vegetation. These increasers, in turn, become less abundant where excessive or untimely grazing is continued, or where fire or insects seriously damage the range. Then, other kinds of plants, called *invaders*, find room to grow. Invaders were not a part of the original vegetation. They are the least desirable of the plants on the range and are practically worthless. Allowing livestock to graze only about half of each season's growth of the potential vegetation, or key forage species, keeps the range from deteriorating and increases the amount of forage produced annually.

The condition of the range is determined by comparing, in kind and number, the plants of the present vegetation with those of the potential vegetation. Condition of the range is related to the amount of increasers, decreasers, and invaders on the site. Four classes of range condition have been recognized. A range in excellent condition has from 76 to 100 percent of the vegetation characteristic of the potential vegetation, or that on the site originally; one in good condition has 51 to 75 percent; one in fair condition has 26 to 50 percent; and one in poor condition has less than 26 percent. Most of the range sites in the Carbon-Emery Area are in poor to fair condition.

Distinguishing one range site from another by examining vegetation alone is not always easy, particularly when the present vegetation differs from the original vegetation. Several different range sites can be covered by the same kinds of increaser and invader plants, and to the casual observer they appear to be the same site. Information obtained from a soil survey generally is needed to help identify a range site.

Estimates of forage yields and plot clippings are needed from an area for several years to determine yields of herbage by site condition. Records of precipitation help to evaluate such yields. The amount of precipitation and the season in which it falls affect the vigor and growth of plants. For example, plot clippings on a Desert Loam range site in poor condition indicate that vegetative production can vary as much as 300 percent between dry years and wet years. Yields of herbage on a site in poor or fair condition fluctuate more than those on a site in good or excellent condition. The production from

[3] WILLIAM G. LEAVELL, Price District Manager, Bureau of Land Management, and his staff; and DONALD H. FULTON, range conservationist, Soil Conservation Service, assisted in preparing this subsection.

perennial plants is less variable than that from annual plants.

Similar soils in different parts of the survey area can produce distinctly different plant communities, and yet the sites can be considered to be in the same condition class. This can be caused by past grazing.

In some places a range site can be easily distinguished. In other places the boundaries are not distinct because gradual changes in relief have caused differences in the amount of precipitation and in the kinds of soils. Areas ungrazed by domestic livestock were not found in the Carbon-Emery survey area. There were several areas from which livestock had been excluded for many years or that had been lightly grazed in recent years. The vegetation potential of the range sites in these areas was studied.

The average annual precipitation on each range site, and the acreage and proportionate extent of each site are shown in table 2. The range sites in the survey area are described on the following pages.

#### DESERT RED SHALE RANGE SITE

This site is along the foothills of Cedar Mountain on the east side of the survey area. It is on hills where the slopes are mainly between 5 and 15 percent but range from 3 to 30 percent. In the survey area, this site is always in poor condition. The average annual precipitation is 7 to 9 inches.

The soil in this range site is Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded. It formed in local alluvium or residuum from the Cedar Mountain geologic formation. This soil is very strongly alkaline and typically is 10 to 20 inches deep over red shale. Its surface layer contains 25 to 50 percent shale fragments.

Galletagrass makes up 60 to 80 percent of the plant cover, and this gives the site the aspect of rolling grassland (fig. 3). There are scattered patches of juniper, and rock crops out in places. Most of the other potentially productive vegetation is Indian ricegrass and squirreltail growing in association with shadscale, Nuttall saltbush, and a variety of forbs. All of the other potential plants grow in small amounts on this site.

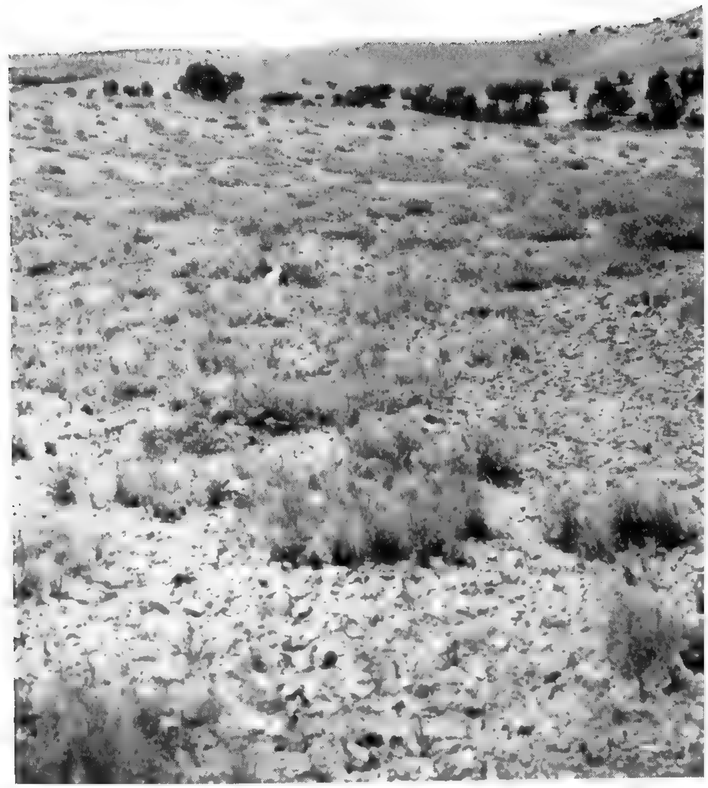

***Figure 3.***—**Range, consisting mainly of galletagrass, on Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded, in the Desert Red Shale range site.**

TABLE 2.—*Range sites in the Carbon-Emery Area, Utah*

| Site | Average annual precipitation | Area | Proportion of survey area |
|---|---|---|---|
| | *Inches* | *Acres* | *Percent* |
| Desert Red Shale | 7 to 9 | 6, 346 | 2 |
| Desert Shale | 7 to 9 | 65, 360 | 19 |
| Desert Loamy Shale | 7 to 9 | 42, 203 | 12 |
| Desert Loam Bottom | 7 to 9 | 79, 561 | 23 |
| Desert Cobbly Loam | 7 to 9 | 37, 777 | 11 |
| Desert Sandy Loam | 7 to 9 | 9, 838 | 3 |
| Semi-Desert Loam Bench | 8 to 10 | 13, 981 | 4 |
| Semi-Desert Limy Loam | 8 to 10 | 10, 114 | 3 |
| Semi-Desert Stony Loam (Pinon-Juniper) | 10 to 12 | 20, 531 | 6 |
| Semi-Desert Stony Hills (Pinon-Juniper) | 9 to 12 | 22, 648 | 7 |
| Salt Meadow | | 21, 878 | 6 |
| Wet Meadow | | 6, 359 | 2 |
| Wet Stream Bottom | | 7, 251 | 2 |
| Total | | 343, 847 | 100 |

Several forbs that have fleshy roots—Indian-potato, desertlily, evening-primrose, and locoweed—grow on this site. These plants can store moisture when it is available and use it during the frequent dry periods.

In its present or potential condition, the production of plants on this range site fluctuates greatly, according to the amount of precipitation. Many annual and perennial flowering plants that are difficult or impossible to find in dry years appear in years of good moisture. This range site has an estimated total potential production of 500 pounds of air-dry forage per acre in favorable years, and of 200 pounds per acre in less favorable years.

#### DESERT SHALE RANGE SITE

This range site is common throughout the survey area. It is on hills that have slopes up to 30 percent, and it is easily recognized by the gray-green color of mat saltbush, the dominant plant, and by the light-gray color of the soil. It is mostly in poor to fair condition. The annual precipitation is 7 to 9 inches.

Soils of the Chipeta series make up this range site (fig. 4). They are silty clays, are less than 20 inches thick

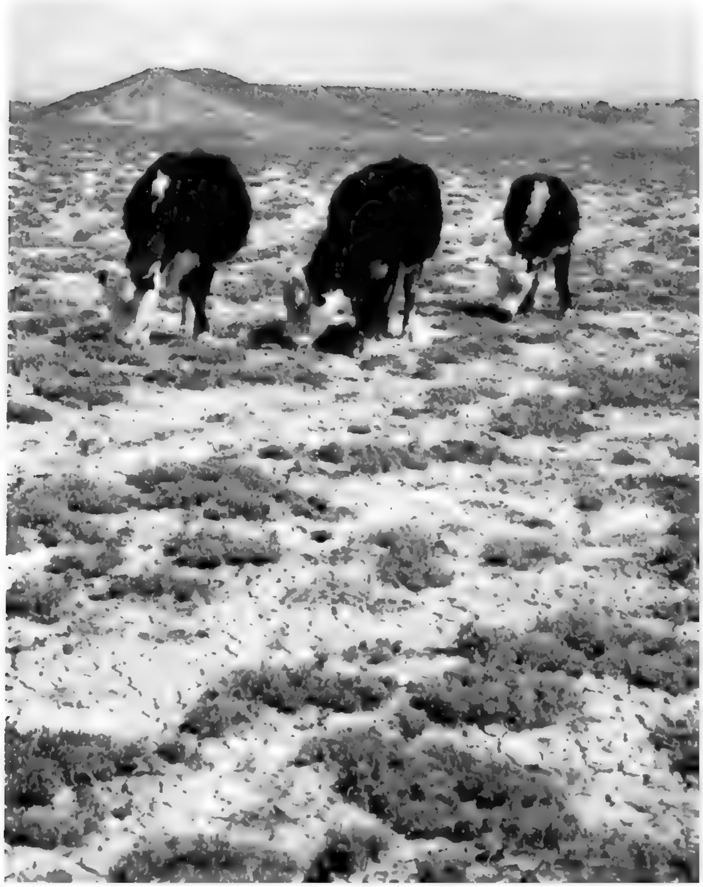

*Figure 4.*—**Cattle grazing mat saltbush on Chipeta silty clay loam, 3 to 30 percent slopes, eroded.**

over gray shale bedrock, and have slopes of up to 30 percent. Accumulations of salts are on the surface. In dry, hot weather a crust one-eighth of an inch thick forms on the surface and retards the infiltration of water. Cracks in the crust divide it into wafers about 2 to 5 inches in diameter, and these are easily crushed under foot. Sheet erosion is active. Runoff from this site causes gullying in range sites lower on the slopes.

The vegetation on this site is 90 to 100 percent mat saltbush. Indian ricegrass, squirreltail, Nuttall saltbush, winterfat, and bud sagebrush are the important decreaser plants. Other important plants, classed as increasers, are bullgrass, galletagrass, mat saltbush, and shadscale. Nuttall saltbush, known locally as Castle Valley clover, and mat saltbush produce most of the forage on this site. Invader plants are foxglove, common sunflower, silverscale, and broom snakeweed. In years of adequate moisture, annual buckwheat and annual bladderpod buckwheat (popweed) grow in large amounts. Sand dropseed is present in trace amounts, but it is doubtful that this plant ever was plentiful enough to be important. It is classed as a decreaser.

Droughtiness and the content of salts in the soil are the causes of the small amount of forage production, even when the site is in its best condition. This range site has a total potential production of 285 pounds of forage per acre, air dry, in favorable years, and of 100 pounds in less favorable years.

### DESERT LOAMY SHALE RANGE SITE

This range site is on round, shaly knolls and shaly slopes, above and interspersed with gently sloping plains. As a rule, this site is situated on slopes above the Desert Loam Bottom range site, and in many places it occurs with the Desert Shale range site. The average annual precipitation is 7 to 9 inches.

Soils of the Persayo series make up this range site (fig. 5). The surface layer is brownish-gray loam about 1 inch thick, and it absorbs moisture readily. Runoff is medium. Gully erosion is active.

All condition classes of this range site have a wide variety of plants, but no mat saltbush. Where this site is in fair to poor condition, galletagrass, blue grama, bullgrass, winterfat, bud sagebrush, shadscale, and yellow rabbitbrush are common plants. Decreaser grasses are Indian ricegrass, squirreltail, and sand dropseed. The increaser grasses are galletagrass, bullgrass, and blue grama. The decreaser shrubs are winterfat, bud sagebrush, and Nuttall saltbush. Increaser shrubs are yellow rabbitbrush, shadscale, gray molly, pricklypear, broom snakeweed, and horsebrush.

*Figure 5.*—**Galletagrass, blue grama, winterfat, shadscale, and bud sagebrush on Persayo loam, 3 to 20 percent slopes, eroded. Desert Loamy Shale range site.**

This range site has a total potential production of 600 pounds of forage per acre, air dry, in favorable years, and of 250 pounds in less favorable years.

#### DESERT LOAM BOTTOM RANGE SITE

This site is in narrow valleys and on broad alluvial plains throughout the survey area. It is near irrigated fields. In most places the site is in poor condition. Livestock tend to congregate on this range site because it is near water (fig. 6). The annual precipitation is 7 to 9 inches, but additional water runs in from adjacent areas.

This range site is composed of deep, medium-textured and moderately fine textured soils of the Billings, Killpack, Penoyer, Ravola, and Woodrow series. These soils have slopes of 0 to 6 percent, but the dominant slopes are between 1 and 3 percent. In some places these soils are saline.

Deep gullies, some of which are 20 to 30 feet deep and 50 to 100 feet wide, are common at the lower elevations. Most of the water that runs in from higher areas flows down the gullies, and this makes the range site drier than it was originally. Vegetation that once held the soil in place and helped to spread runoff water is now difficult to find.

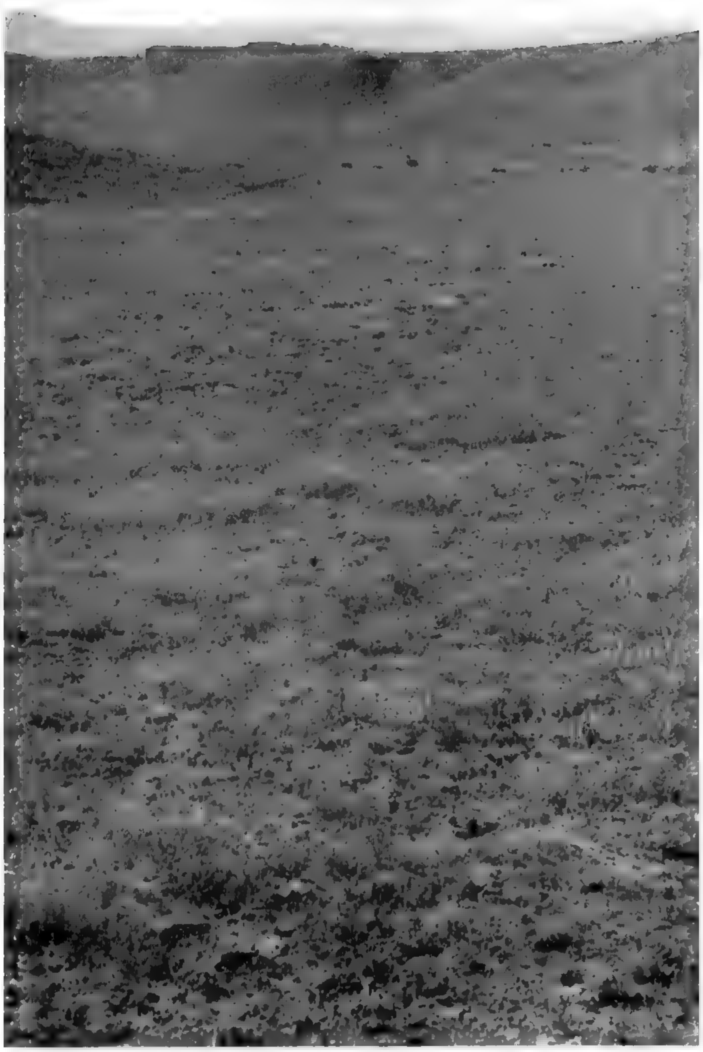

*Figure 6.*—**Annual weeds, mainly Russian-thistle, are dominant on Ravola loam, 1 to 3 percent slopes, when the range is in poor condition. Desert Loam Bottom range site.**

Remnants of Great Basin wildrye, alkali sacation, Indian ricegrass, squirreltail, and sand dropseed indicate that these are the important decreaser grasses on this range site. Together they make up 50 to 60 percent of the potential vegetation.

Galleta, blue grama, bullgrass, and three-awn are the increaser grasses. They make up 15 to 20 percent of the potential vegetation. Other plants are scarlet globemallow, desert plantain, aster, locoweed, bud sagebrush, Nuttall saltbush, greasewood, and winterfat. The less important plants are shadscale, fringed sagebrush, big sagebrush, and rubber rabbitbrush. Invaders are broom snakeweed, pricklypear, Russian-thistle, and annuals.

Erosion has changed the potential plant composition and has lowered the production of forage. To restore the gullied areas to productivity requires diversion terraces and water spreading to reduce further gullying and to make use of water that runs in from higher areas. A method for safely disposing of waste irrigation water may also be needed. To achieve proper results, mechanical treatments need to be followed by good range management.

This range site has a total potential production of 750 pounds of forage per acre, air dry, in favorable years, and of 325 pounds in less favorable years.

#### DESERT COBBLY LOAM RANGE SITE

This range site consists of Shaly colluvial land on steep breaks or escarpments below benches or mesas that are as much as 200 feet high. The soil material is a mixture of cobblestones, stones, and finer materials that have fallen and rolled downslope from cobbly glacial outwash caps on benches. This material is as much as 36 inches thick. Slopes range from 1 to 70 percent, but mainly they are about 30 percent. Outcrops of shale are common on the steep slopes. The annual precipitation is 7 to 9 inches.

In a few places, these colluvial slopes extend for more than a mile to form a long cobbly fan. In addition, a few isolated hills that rise from the valley floor are covered by a thin mantle of cobbly loam over Mancos shale. The cobbly loam over shale provides good soil and plant-moisture relations and produces a much different type of vegetation than grows on the Desert Shale range site. The surface layer of the soil material on this range site ranges from gray to light brown, but as a rule it is brown. Under this is blue-gray shale. Fragmented brown sandstone rocks and gravel make up about 50 percent of the surface layer.

Western wheatgrass and black sagebrush grow on this site, but evidently they were never important plants. The potentially important plants are Indian ricegrass, needle-and-thread, squirreltail, bud sagebrush, winterfat, Mormon-tea, and cliffrose. These are choice plants for livestock. Also important are bullgrass, galletagrass, western wheatgrass, blue grama, sand dropseed, shadscale, black sagebrush, yellow rabbitbrush, and scarlet globe-

mallow. In years that moisture is above normal in quantity, the other important plants are Indian-potato, phlox, evening-primrose, and desertlily.

This site has a total potential production of 550 pounds of forage per acre, air dry, in favorable years, and of 250 pounds in less favorable years.

#### DESERT SANDY LOAM RANGE SITE

The largest and most representative single area of this site is on Walker Flat, south of Emery, Utah. Small areas are also in the northern and eastern parts of the survey area. This site occupies alluvial fans and flood plains. Slopes range from 0 to 6 percent but mainly are 3 to 4 percent.

Soils of the Beebe and Penoyer series make up this range site. They are deep loamy fine sands and very fine sandy loams. They absorb moisture readily, and because of this plants respond quickly to light summer showers. These soils are highly susceptible to wind erosion.

The potential plant cover on this site is winterfat, four-wing saltbush, Indian ricegrass, sand dropseed, squirreltail, scarlet globemallow, and Sandberg bluegrass. Where this range site is in excellent condition, four-wing saltbush makes up a large proportion of the forage.

Blue grama is an increaser on this range site, but it makes up 30 to 50 percent of the total herbage when this site is in fair or good condition. Less than 10 percent of the vegetation is greasewood and big sagebrush. Common invaders are cheatgrass, broom snakeweed, pricklypear, and annual weeds. Where this site is in excellent condition, less than 20 percent of the vegetation is galletagrass, fringed sagebrush, shadscale, and Nuttall saltbush.

This range site has a total potential production of 800 pounds of forage per acre, air dry, in favorable years, and of 400 pounds in less favorable years.

#### SEMI-DESERT LOAM BENCH RANGE SITE

This site is along the west side of the survey area, where long benches project from the eastern foothills of the Wasatch Mountains. These benches lie in an east-west direction, slope gradually to the east, and are dissected by numerous draws and a few intermittent streams. This range site is also on a few isolated mesas in the central part of the survey area. The average annual precipitation is 8 to 10 inches.

The Semi-Desert Loam Bench range site is associated with the Semi-Desert Limy Loam range site, and both are commonly interspersed. The Semi-Desert Loam Bench range site consists of Minchey and Palisade loams and clay loams that have slopes of 1 to 10 percent. As a rule, these soils are more than 30 inches deep over gravel. A moderate amount of lime generally is in the surface layer. Low or black sagebrush does not grow on these soils (fig. 7). The Price airport bench and Prophyry bench, both dominantly covered by big sagebrush, are included in this range site.

Benches grazed by sheep in winter have a grassland aspect; those grazed by cattle in spring have a browse aspect. For example, the bench south of Ivie Creek, grazed by sheep in winter, is dominantly galletagrass; the one north of Castle Dale, grazed by cattle in spring, is dominantly browse. Both benches have similar soils and are in the same range condition class.

***Figure 7.*—Winterfat and yellow rabbitbrush are dominant on Palisade very fine sandy loam, 1 to 3 percent slopes. Semi-Desert Loam Bench range site.**

Important decreaser plants in this range site are Indian ricegrass, needle-and-thread, squirreltail, winterfat, bud sagebrush, and Nuttall saltbush. The common invaders of this site are broom snakeweed and annual weeds.

This range site has a total potential production of 950 pounds per acre, air dry, in favorable years, and of 500 pounds in less favorable years.

#### SEMI-DESERT LIMY LOAM RANGE SITE

This range site occupies the ridges on benchlands. The bench above Castle Dale and the benches between Emery and Moore are mainly in this range site. In most places this range site occurs with the Semi-Desert Loam Bench range site, but it is easily distinguished by the presence of low-growing black sagebrush. Pygmy sagebrush is common on the Harding soil. In some places the vegetation on these two associated range sites tends to merge and form a transitional zone. The annual precipitation is 8 to 10 inches.

Soils in the Harding, Minchey, and Sanpete series made up this range site. The surface layer is moderately fine textured, and the profile has a high content of lime. As a rule, a concentration of lime is between 10 and 30 inches. Roots are somewhat restricted but penetrate this limy

layer. This restriction in rooting causes the vegetation on this range site to be slightly less productive and to show the effects of drought earlier than on the Semi-Desert Loam Bench range site.

The potential vegetation on the Semi-Desert Limy Loam range site is Indian ricegrass, needle-and-thread, squirreltail, winterfat, bud sagebrush, Nuttall saltbush, black sagebrush, low sagebrush, gray molly, and Mormon-tea. These plants make up about 15 to 20 percent of the total vegetation. Galletagrass makes up more of the potential vegetation on this range site than it does on the less droughy Semi-Desert Loam Bench range site.

The potential production on the Semi-Desert Limy Loam range site is 750 pounds of forage per acre, air dry, in favorable years, and 350 pounds in less favorable years.

#### SEMI-DESERT STONY LOAM (PINON-JUNIPER) RANGE SITE

This range site is on mesas and benches in the foothills and lower breaks of the Wasatch Mountains. Slopes range from 2 to 60 percent but mainly are 3 to 10 percent. Juniper trees makes up from 60 to 80 percent of the overstory; the rest is pinon. The annual precipitation is 10 to 12 inches.

Stony alluvial land and Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded, make up this range site. Gravel, cobblestones, and stones comprise most of the profile. In places there are large boulders.

The original vegetation in the understory is so badly depleted that remnants of grass are hard to find in most places. Erosion is active as indicated by weak pediceled shrubs and exposed roots of juniper and pinon trees. Roots of the present vegetation spread through the soil and use moisture that once was available to palatable range plants. This site has been damaged to the extent that it may never recover and produce the kinds of plants that once grew there (fig. 8). If domestic livestock are excluded, deer utilize all forage produced. Some deer live here the year around and consume whatever forage is available. Deep snow in the high country causes deer to concentrate on this site, and they consume even the juniper branches within their reach.

This site is in excellent condition on Wood Hill north of Price. Here, Indian ricegrass is 85 percent of the understory vegetation. Squirreltail, needle-and-thread, bullgrass, and sand dropseed make up 5 percent; phlox, scarlet globemallow, penstemon, locoweed, and aster make up 5 percent; and birchleaf mahogany, bitterbrush, cliffrose, dwarf mahogony, Mormon-tea, and mockorange make up 5 percent.

On Wood Hill this site produced 1,250 pounds of forage per acre, air dry, in 1957; it produced 900 pounds in 1961. The annual needle and twig growth of juniper and pinon was estimated to be 40 to 50 percent of the total production. Firewood, posts, pine nuts, and Christmas trees are other products taken from this site.

#### SEMI-DESERT STONY HILLS (PINON-JUNIPER) RANGE SITE

This range site is on the east and west sides of the survey area. It occurs with steep rock outcrops, which make up as much as 40 percent of the site in some places.

The soil in this site is Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded. It is medium textured, gravelly, and 10 to 20 inches thick over bedrock. The content of organic matter is low. The susceptibility to wind erosion is high in places where the range is in poor condition. The forage potential is low because this soil is shallow and has a low moisture-retaining capacity. Where pinon and juniper are dominant on the site, few plants are in the understory and improvement of range condition is slow.

In 1961 production of forage on this site was measured on a mesa in an adjoining area that had been grazed by deer but never by domestic livestock. It produced a total of 327 pounds of air-dry forage per acre from the following plants: 94 pounds, or 29 percent, from bullgrass; 185 pounds, or 55 percent, from pinon and juniper; and 48 pounds, or 16 percent, from all of the following plants combined: dryland sedge, bluebunch wheatgrass, penstemon, mat buckwheat, hairy golden-aster, rock goldenrod, woody phlox, and shadscale.

The potential plant cover on this site is about 57 percent pinon and juniper. Other species making up about 40 percent are Indian ricegrass, blue grama, galletagrass, perennial mustard, senecio, milkweed, birchleaf mahogany, pricklypear, Mormon-tea, and winterfat.

This range site has a total potential production of 450 pounds of forage per acre, air dry, in favorable years, and of 100 pounds in less favorable years. Pinon and juniper trees are scrubby and they grow slowly. The firewood and posts produced on the site have little economic value.

#### SALT MEADOW RANGE SITE

This range site consists of saltgrass meadows on lower elevations to which seepage and irrigation waste water flow to supply additional moisture. The amount of water this site gets each year is variable, and because of this the content of salts in the soil is variable.

Soils of the Abbott, Libbings, and Saltair series make up this site (fig. 9). They are strongly saline, deep and moderately deep silty clays and silty clay loams. The water table fluctuates and may be below the root zone part of the year.

Alkali sacaton, alkali bluegrass, and tufted hairgrass are the decreaser plants. Poor management will result in a 100-percent stand of saltgrass. Foxtail, sedges, and wiregrass are the increasers. Greasewood and willow make up less than 5 percent of the total vegetation. Saltcedar (tamarisk), bassia, and alkaliweed are invader plants.

This range site has a total potential production of 1,700 pounds of forage per acre, air dry, in favorable years, and of 900 pounds in less favorable years. These estimates do not include forage produced in slightly elevated, highly saline areas in which only greasewood and other salt-tolerant plants can survive.

#### WET MEADOW RANGE SITE

This range site is on alluvial bottom lands and flood plains and is wet during the growing season. Soils of the Abbott, Ferron, Killpack variant, Palisade variant, and Rafael series make up this site. They are deep, and their texture ranges from clay to loam.

The decreaser plants are tufted hairgrass, redtop, and native clover. Sedges, wiregrass, cinquefoil, goldenrod, buttercup, plantain, and arrowgrass are the increasers.

*Figure 8—Top,* Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded, in poor range condition. *Bottom,* another area of the same kind of soil in excellent range condition. Semi-Desert Stony Loam (Pinon-Juniper) range site.

*Figure 9.*—**Saltgrass is dominant in this area of Saltair silty clay loam. Salt Meadow range site.**

The potential forage production on this site depends on the fertility of the soils and on the length of the growing season. It ranges from 2,000 to 2,500 pounds per acre, air dry.

#### WET STREAM BOTTOM RANGE SITE

This range site consists of bottom lands of streams between the channel banks and the steep side slopes of adjacent higher land. It occurs mainly along the Price River and Muddy, Huntington, Cottonwood, and Ferron Creeks. The site is flooded in spring and is later flooded by runoff from summer thundershowers of high intensity.

Mixed alluvial land makes up this site. This material is deep, is stratified, and ranges in texture from clays to sands. In some places gravel is within 10 inches of the surface. The water table is near the surface in most places, but the depth to it depends on seasonal fluctuations of the stream level. Some areas are not affected by salt, and some are moderately affected. A good sod on the surface helps prevent gullying.

The decreaser plants are slender wheatgrass, alkali bluegrass, and native and tame clovers. The important increasers are alkali sacaton, squirreltail, wiregrass, saltgrass, giantreed, willow, cottonwood, buffaloberry, and squawbush. Common invaders are povertyweed, rubber rabbitbrush, saltcedar (tamarisk), and annual weeds.

This range site has a total potential production of 2,500 pounds of forage per acre, air dry, in favorable years, and of 1,500 pounds in less favorable years.

## Use of the Soils for Wildlife [4]

All kinds of wildlife require suitable habitat that provides enough food, water, and living space to support their daily activity. If the landowner insures that these elements of wildlife habitat are plentiful, the wildlife population in an area will increase.

The kinds of wildlife that live in a given area and the number of each kind are closely related to land use and the resulting kinds and patterns of vegetation. These, in turn, are generally related to the kinds of soils. The agricultural uses of the soils are correlated with their suitability for wildlife. Nonirrigated land in farms may provide living space and cover but little food or water; irrigated land provides the food and water, especially during summer and fall.

In the following paragraphs wildlife and fish are discussed in two categories because the distribution of wildlife depends on kinds of landscapes, or soil associations, but the distribution of fish depends on locations of water sources and suitable farm ponds.

**Wildlife.**—The survey area is divided into three wildlife suitability groups, according to soil associations. Several soil associations have been grouped because of similarities in land use, or plant cover, or both. The colored general soil map at the back of this survey outlines the boundaries of the different soil associations. More complete descriptions of the associations are given in the section "General Soil Map."

#### WILDLIFE SUITABILITY GROUP 1

This group consists of irrigated soils, wet soils, and soils in stream channels. These are the Chipeta and Killpack soils in association 1; the Ravola, Billings, and Penoyer soils in association 2; the Saltair and Libbings soils in association 3; and the Sanpete and Minchey soils in association 4. Kinds of wildlife adapted to these soils are Chinese pheasant, mourning dove, cottontail rabbit, ducks, geese, muskrat, and beaver. The Chinese pheasant is the most important bird in this suitability group.

#### WILDLIFE SUITABILITY GROUP 2

This group consists of the nonirrigated soils in associations listed in wildlife suitability group 1, and of the Chipeta and Persayo soils and Badland of association 5. Kinds of wildlife suited to these soils are chukar partridge and cottontail rabbit. Pheasant and mourning dove nest and seek cover here. Mule deer cross these soils when migrating, or they temporarily live here in winters of deep snow.

#### WILDLIFE SUITABILITY GROUP 3

This group consists of the rest of the survey area, mainly foothills covered by pinon and juniper. In this group are the Castle Valley and Kenilworth soils and Rock land of association 6. Kinds of wildlife suited to these soils are mule deer, chukar partridge, and cottontail rabbit. Mule deer summer in the forest adjacent to the survey area.

**Fish.**—In addition to wildlife on land, fish are important in the survey area. Some trout are in the Price and Muddy Rivers and in Ferron, Huntington, and Cottonwood Creeks above the main diversions for irrigation water. These streams, however, are subject to flooding, and the lower reaches near diversions are not managed as fisheries by the State government.

Below points of diversion, permanent watercourses are adversely affected by salty seepage water and are inhabited only by trash fish. The Green River has no management program, yet 14 species of fish live in it. Of these, the channel catfish is the only game fish.

A number of farm ponds have been stocked in the past with bass and bluegill. Current practice is to stock farm

[4] SCOTT B. PASSEY, area conservationist, Soil Conservation Service, helped prepare this section of the soil survey.

ponds, mainly with rainbow trout. The lack of good springs and of underground water of good quality restricts the construction and development of farm ponds. Most fishponds in existence are fed by irrigation water.

## Engineering Properties and Behavior of Soils [5]

Some soil properties are of special interest to engineers because they affect the construction, maintenance, and performance of roads, airports, pipelines, building foundations, facilities for water storage, erosion-control structures, drainage systems, and sewage disposal systems. Soil properties that are most important to the engineer are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, grain size, plasticity, and reaction. Also important, however, are depth to the water table, to bedrock, or to a hardpan; content of salt and alkali; and topography.

The information in this soil survey can be used by engineers to—

1. Make studies of soil and land use that will aid in selecting and developing sites for industries, businesses, residences, and recreation.
2. Obtain estimates of the amount of runoff and the erosion characteristics of the soils, for use in designing drainage structures and in planning dams and other structures for use in conserving soil and water.
3. Make reconnaissance surveys of soil and site conditions that will aid in selecting locations for highways and airports and in planning detailed soil surveys for the intended locations.

[5] WILLIAM J. MORGAN, (deceased), engineer, Soil Conservation Service, assisted in preparing this section.

TABLE 3.—*Estimated soil properties*

[Badland (Ba), Gullied land (Gu), Mixed alluvial land (Mx), Riverwash (Rv), Rock land (Ry), Shaly colluvial land (Sn), and Stony alluvial land (Ry), the depth to a seasonal water table is more

| Soil series and map symbols | Depth to seasonal water table | Depth to bedrock | Depth from surface (typical profile) | Classification | | |
|---|---|---|---|---|---|---|
| | | | | USDA texture | Unified | AASHO |
| | *Inches* | *Inches* | *Inches* | | | |
| Abbott (Ab, As) | 6–40 | 60+ | 0–60 | Silty clay and silty clay loam. | CL | A–7 |
| Beebe (BbB, BeB, BeC2, BfA) | 72+ | 60+ | 0–71 | Loamy fine sand | SM | A–4 |
| Billings (BlB, BlC2, BsB, BtB, BuB2) (For properties of the Bunderson soil in mapping unit BuB2, refer to the Bunderson series.) | (1) | 60+ | 0–72 | Silty clay loam | CL | A–6 |
| Bunderson. (Mapped only in complexes with the Billings and Ravola soils.) | 72+ | 60+ | 0–72 | Loam | CL | A–4 |
| Cache (Ca) | 20–40 | 60+ | 0–60 | Silty clay | CL | A–7 |
| Castle Valley (CeE2) | 72+ | 10–20 | 0–10<br>10 | Very fine sandy loam<br>Sandstone. | ML | A–4 |
| Cedar Mountain (CmF2) | 72+ | 10–20 | 0–14<br>14 | Shaly silty clay, clay loam, and silt loam.<br>Shale. | ML–CL | A–6 |
| Chipeta (CBF2, CPB, CPE2) (For properties of the Persayo soils in mapping units CPB and CPE2, refer to the Persayo series. Badland in mapping unit CBF2 is too variable to rate. | 72+ | 10–20 | 0–17<br>17 | Silty clay loam<br>Shale. | CL | A–6 or A–7 |
| Ferron: | | | | | | |
| (Fr) | 6–36 | 60+ | 0–60 | Loam and very fine sandy loam. | ML–CL | A–4 |
| (Fe) | 6–36 | -------- | 0–60 | Silty clay loam and silt loam. | CL | A–6 |
| Green River (Gr) | 20–40 | 60+ | 0–45<br>45–60 | Stratified loam and very fine sandy loam.<br>Fine sand | CL–ML<br>SM | A–4<br>A–2 |

See footnotes at end of table.

4. Locate probable sources of sand and gravel for use in structures and as a base for both flexible and rigid pavements.
5. Correlate pavement performance with kinds of soil, and thus develop information that will be useful in designing and maintaining pavements.
6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps and reports and from aerial photographs.
8. Become aware of hazards or of useful properties of soils to be used for highways and earth construction where definite laboratory data are not available.

With the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized, however, that they may not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads or where the excavations are deeper than the depth of layers here reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Much of the information in this subsection is in tables 3, 4, and 5. In table 3 properties of soils that are important to engineering are estimated. Table 4 indicates the suitability of soils for various engineering uses. Table 5 gives test data for soils of several soil types that are extensive in the survey area.

*significant to engineering*

land (St) are omitted from this table, because their properties generally are too variable to estimate. For Badland (Ba) and Rock than 72 inches and bedrock is at or near the surface]

| Percentage passing sieve— | | | Percentage larger than 3 inches | Permeability | Available water capacity | Reaction (paste) | Salinity | Dispersion | Shrink-swell potential | Hydrologic groupings |
|---|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm.) | No. 10 (1.0 mm.) | No. 200 (0.074 mm.) | | | | | | | | |
| | | | | *Inches per hour* | *Inches per inch of soil depth* | *pH* | | | | |
| 100 | 100 | 90–95 | -------- | 0. 05–0. 2 | 0. 19 | 7. 1–7. 9 | Slight to strong. | Low to moderate. | Moderate--- | D |
| 100 | 100 | 35–45 | -------- | 5. 0–10. 0 | 0. 06–0. 10 | 7. 9–9. 7 | None to moderate. | None------ | Low------- | A |
| 100 | 100 | 85–95 | -------- | 0. 05–0. 2 | 0. 17–0. 2 | 7. 6–8. 6 | Slight to moderate. | Moderate--- | Moderate--- | C |
| 100 | 100 | 70–90 | -------- | (2) | 0. 13–0. 15 | 8. 5–10. 0 | Moderate to high. | High------- | Low------- | D |
| 100 | 100 | 90–100 | -------- | 0. 05–0. 2 | 0. 15–0. 17 | 7. 9–8. 5 | Very strong--- | High------- | Moderate--- | D |
| 95–100 | 85–100 | 50–60 | 5–10 | 2. 5–5. 0 | 0. 13–0. 15 | 7. 5–8. 0 | None-------- | Low------- | Low------- | D |
| 100 | 95–100 | 85–90 | 5–10 | 0. 05–0. 2 | 0. 12–0. 14 | 8. 0–8. 5 | None-------- | Moderate--- | Moderate-- | D |
| 100 | 100 | 90–97 | -------- | 0. 05–0. 2 | 0. 15–0. 17 | 7. 4–8. 0 | Moderate to strong. | Moderate--- | Moderate--- | D |
| 100 | 100 | 80–90 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 7–8. 5 | Slight to strong. | Low------- | Low------- | B |
| 100 | 100 | 90–95 | -------- | 0. 2–0. 8 | 0. 17–0. 19 | 7. 7–8. 5 | Moderate----- | Moderate--- | Moderate--- | B |
| 100 | 100 | 70–80 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 8–8. 2 | None to slight. | Low------- | Low------- | B |
| 100 | 90–100 | 15–20 | -------- | 2. 5–5. 0 | 0. 08–0. 11 | 7. 8–8. 2 | None to slight. | Low------- | None------ | B |

TABLE 3.—*Estimated soil properties*

| Soil series and map symbols | Depth to seasonal water table | Depth to bed-rock | Depth from surface (typical profile) | Classification: USDA texture | Classification: Unified | Classification: AASHO |
|---|---|---|---|---|---|---|
| | *Inches* | *Inches* | *Inches* | | | |
| Harding (Ha) | 72+ | 60+ | 0–10 | Clay loam | CL | A–6 |
| | | | 10–20 | Clay | CL | A–7 |
| | | | 20–52 | Clay loam and loam | CL | A–6 |
| Hunting (Hn, Hs, Hu) | 20–40 | 60+ | 0–60 | Loam | CL | A–4 |
| Kenilworth (KeE2) | 72+ | 60+ | 0–34 | Stony sandy loam | SM | A–2 or A–4 |
| Killpack (KlB, KlC2, KmB, KpB, KpC2) | ([1]) | 20–40 | 0–23 | Clay loam or loam | ML–CL | A–4 |
| | | | 23–29 | Shaly silty clay loam | CL | A–6 |
| | | | 29 | Shale. | | |
| Libbings (Lb, Ls) | 10–30 | 20–40 | 0–34 | Silty clay loam, clay, and silty clay. | CL | A–6 |
| | | | 34 | Shale. | | |
| Minchey (McB, MlB, MsB, MsC2) (For properties of the Sanpete soils in mapping units MsB and MsC2, refer to the Sanpete series.) | 72+ | 60+ | 0–32 | Clay loam | CL | A–6 |
| | | | 32–64 | Gravelly sandy loam | MG–GC | A–4 and A–2. |
| Palisade (PaB, PdB, PdC2) | ([4]) | 60+ | 0–41 | Very fine sandy loam | ML–CL | A–4 |
| | | | 41–60 | Very fine sandy loam | SM | A–4 |
| Penoyer: | | | | | | |
| (PeB, PeC2, PhD, PnA, PsB, PsC2, PvB2) | 72+ | 60+ | 0–60 | Loam | CL | A–6 |
| (PrA, PoB) | | | 0–14 | Silty clay loam | CL | A–4 |
| | | | 14–60 | Loam | CL–ML | A–4 |
| Persayo (PCE2) (For properties of the Chipeta soil in this mapping unit, refer to Chipeta series.) | 72+ | 6–20 | 0–12 | Loam and silty clay loam. | CL | A–4 |
| | | | 12 | Shale. | | |
| Rafael (Ra) | 6–30 | 60+ | 0–70 | Silty clay loam and loam. | CL | A–4 |
| Ravola (RlB, RlB2, RlC2, RnD, RsA, RsB, RtB, RuB2) (For properties of the Bunderson soil in mapping unit RuB2, refer to the Bunderson series.) | 72+ | 60+ | 0–60 | Loam | ML–CL | A–4 |
| Saltair (Sa, Sb) | 6–60 | 60+ | 0–60 | Silty clay loam and silt loam. | CL | A–4 |
| Sanpete (SlB, SlD2, SmD2) (For properties of the Minchey soil in mapping unit SmD2, refer to the Minchey series.) | 72+ | 60+ | 0–14 | Gravelly sandy clay loam. | ML–CL | A–4 |
| | | | 14–30 | Very cobbly sandy clay loam. | SM | A–4 |
| Woodrow (Wo) | 72+ | 60+ | 0–60 | Silty clay loam. | CL | A–4 |

[1] In the Billings and Killpack soils, the seasonal water table is at a depth of more than 72 inches, except that it is between 36 and 60 inches in mapping unit BsB and between 20 and 40 inches in mapping unit KmB.
[2] Less than 0.05 inch per hour in surface layer; 0.8 to 2.5 inches per hour below a depth of 10 to 20 inches.

*significant to engineering*—Continued

| Percentage passing sieve— No. 4 (4.7 mm.) | No. 10 (1.0 mm.) | No. 200 (0.074 mm.) | Percentage larger than 3 inches | Permeability | Available water capacity | Reaction (paste) | Salinity | Dispersion | Shrink-swell potential | Hydrologic groupings |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Inches per hour* | *Inches per inch of soil depth* | *pH* | | | | |
| 95–100 | 95–100 | 75–85 | -------- | 0. 05–0. 8 | 0. 19–0. 21 | 8. 1–8. 7 | Moderate | High | Moderate | C |
| 95–100 | 95–100 | 75–85 | -------- | (3) | 0. 16–0. 18 | 8. 1–8. 7 | Moderate to strong. | High | Moderate | C |
| 75–80 | 65–75 | 70–80 | -------- | 0. 8–2. 5 | 0. 16–0. 18 | 8. 3–8. 7 | Moderate to strong. | High | Moderate | C |
| 100 | 100 | 70–80 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 8–8. 3 | Slight to strong. | Low | Moderate | B |
| 50–75 | 45–70 | 25–40 | 20 50 | 0. 8 2. 5 | 0. 10–0. 12 | 7. 7–8. 5 | None | Low | Low | B |
| 100 | 100 | 70–80 | -------- | 0. 2 0. 8 | 0. 19–0. 21 | 7. 7–8. 0 | Slight to moderate. | Moderate | Moderate | C |
| 80–95 | 70–90 | 65–85 | -------- | 0. 2–0. 8 | 0. 19–0. 20 | 7. 7–8. 0 | Slight to moderate. | Moderate | Moderate | C |
| 100 | 80–95 | 90–100 | -------- | 0. 05–0. 2 | 0. 16–0. 18 | 8. 2–8. 9 | Very strong | Moderate | Moderate | D |
| 95–100 | 95–100 | 60–75 | -------- | 0. 8–2. 5 | 0. 19–0. 21 | 7. 9–8. 3 | None | Low | Moderate | B |
| 55–85 | 50–80 | 30–40 | 5 | 1. 25–5. 0 | 0. 06–0. 09 | 7. 9–8. 3 | None | Low | Low | |
| 85–95 | 80–90 | 50–60 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 5–8. 0 | None | Low | Low | B |
| 85–95 | 80–90 | 35–45 | 0 | 2. 5–5. 0 | 0. 07–0. 10 | 7. 5–8. 0 | None | Low | Low | B |
| 100 | 100 | 70–80 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 7–8. 2 | None | Low | Low | B |
| 100 | 100 | 90–95 | -------- | 0. 2–0. 8 | 0. 19–0. 21 | 7. 7–8. 2 | None | Low | Moderate | B |
| 100 | 100 | 70–80 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 8–8. 2 | Slight | Low | Low | B |
| 80–85 | 70–80 | 65–75 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 5–8. 0 | Slight to strong. | Moderate | Moderate | D |
| 100 | 95–100 | 75–85 | -------- | 0. 05–0. 2 | 0. 17–0. 19 | 7. 7–8. 6 | Moderate to strong. | Moderate | Moderate | D |
| 100 | 100 | 75–85 | -------- | 0. 8–2. 5 | 0. 17–0. 19 | 7. 7–8. 0 | None to moderate. | Low | Low | B |
| 100 | 100 | 85–95 | -------- | 0. 05–0. 2 | 0. 16–0. 18 | 8. 3–8. 9 | Very strong | High | Moderate | D |
| 99–100 | 90–100 | 50–60 | 10–20 | 2. 5–5. 0 | 0. 10–0. 13 | 7. 9–8. 5 | None | Low | Low | A |
| 70–80 | 65–75 | 40–50 | 20 | 2. 5–5. 0 | 0. 06–0. 08 | 7. 9–8. 5 | None | Low | Low | A |
| 100 | 100 | 90–95 | -------- | 0. 05–0. 2 | 0. 19–0. 21 | 7. 6–7. 9 | None to slight. | Low | Moderate | C |

[3] Less than 0.05 inch per hour.

[4] In the Palisade soils, mapping unit PaB has a seasonal water table at a depth between 10 and 45 inches. In all other Palisade soils, the water table is lacking.

TABLE 4.—*Interpretation of engineering properties*

[Rock land (Ry) is omitted from table because onsite

| Soil series and map symbols | Suitability as a source of— | | | | Suitability for winter grading | Suscepti-bility to frost action |
|---|---|---|---|---|---|---|
| | Topsoil | Sand | Gravel | Road fill | | |
| Abbott (Ab, As) | Not suitable | Not suitable | Not suitable | Fair | Poor | Moderate |
| Badland (Ba) | Not suitable | Not suitable | Not suitable | Poor | Poor | Moderate |
| Beebe (BbB, BeB, BeC2, BfA) | Fair to good | Very fine to medium sand. | Not suitable | Good | Good | Low |
| Billings (BlB, BlC2, BsB, BtB, BuB2) (For interpretations of the Bunderson soil in BuB2, refer to the Bunderson series.) | Fair in surface layer. | Not suitable | Not suitable | Fair to good. | Fair | High |
| Bunderson | Not suitable | Not suitable | Not suitable | Poor | Good | High to low |
| Cache (Ca) | Not suitable | Not suitable | Not suitable | Poor | Poor | Moderate; too salty to freeze. |
| Castle Valley (CeE2) | Fair | Poor; very fine sandy loam. | Not suitable | Fair | Good | Moderate |
| Cedar Mountain (CmF2) | Poor | Not suitable | Not suitable | Fair | Fair | Moderate |
| Chipeta (CBF2, CPB, CPE2) (For interpretations of the Badland mapping unit in CBF2, refer to the Badland mapping unit; for interpretations of the Persayo soils in CPB and CPE2, refer to the Persayo series.) | Poor | Not suitable | Not suitable | Fair | Fair | Moderate |
| Ferron (Fe, Fr) | Good | Not suitable | Not suitable | Fair if drained. | Poor | High |
| Green River (Gr) | Good | Not suitable | Not suitable | Good | Good | High |
| Gullied land (Gu) | Good | Not suitable | Not suitable | Fair | Fair | High |
| Harding (Ha) | Not suitable | Not suitable | Subsoil fair for road gravel. | Good | Good | Moderate |
| Hunting (Hn, Hs, Hu) | Good | Not suitable | Not suitable | Good | Fair | Moderate |
| Kenilworth (KeE2) | Good | Not suitable | Subsoil has suitable crushing rock for gravel. | Good | Good | Low |

*of soils in the Carbon-Emery Area, Utah*

investigation is required to determine its suitability]

| Soil features affecting suitability for— | | | | | |
|---|---|---|---|---|---|
| Highway location | Dikes or levees | Farm ponds | | Agricultural drainage | Irrigation |
| | | Reservoir area | Embankment | | |
| High water table; subject to frost action. | Low to medium shear strength. | Slow permeability | Low to medium shear strength. | Subsurface drainage difficult; fine texture; adverse dip of bedrock. | High water table. |
| Poor foundation material. | Shale bedrock at a depth of less than 10 inches. | Shale bedrock at a depth of less than 10 inches; rapid seepage. | Limited by steep slopes and shallowness over shale. | Drainage not needed. | Shallowness over shale; too steep to be suitable for irrigation. |
| No limitations | Fine sand; unstable | Rapid permeability | Low strength and stability. | Rapid permeability; drainage not needed. | Rapid permeability; low water-holding capacity. |
| No limitations | Fair stability; susceptibility to piping; cracks when dry. | Slow permeability | Cracks when dry; low shear strength; contains gypsum. | Slow permeability; subsurface drainage satisfactory. | Slow permeability. |
| Fair | Unstable | Very slow permeability. | Highly dispersed | Not needed | Highly dispersed; poorly suited to irrigation. |
| High water table; subject to frost action. | Low shear strength | Slow permeability | Low shear strength; slow permeability. | Subsurface drainage difficult; soil material fine textured. | Strong salinity; high water table. |
| Less than 20 inches deep over sandstone bedrock. | Fine sand; shallow over sandstone. | Moderately rapid permeability. | Low strength and stability. | Not needed | Not suitable for irrigation. |
| Less than 20 inches deep over shale bedrock. | Shallow over shale; suitable for borrow. | Shallow over shale; slow seepage along shale bedrock. | Low to moderate shear strength. | Not needed | Not suitable for irrigation. |
| Less than 20 inches deep over shale bedrock. | Cracks when dry; shallow over shale. | Shallow over shale; seepage along shale. | Gypsum in subsoil; low shear strength. | Not needed | Shallow over shale; poor agricultural soil. |
| High water table; subject to frost action. | Fair stability | Moderate to slow permeability. | Moderate shear strength. | Subsurface drainage difficult; occupies low areas; adverse bedrock dip. | High water table; moderate to moderately slow permeability. |
| Water table below 36 inches. | Fair stability | Moderate permeability. | Moderate shear strength. | Underlain by gravel; drainage satisfactory if outlets are available. | Moderate permeability. |
| Gullies 5 to 15 feet deep. | Fair stability | Moderate to slow permeability. | Moderate shear strength. | Network of gullies; drainage not needed. | Not suitable for irrigation. |
| No limitations | High shear strength | Very slow permeability in subsoil. | High shear strength, but permeable. | Not needed | Poorly suited to irrigation; alkali affected. |
| Water table between 20 and 40 inches. | Fair stability | Moderate permeability. | Moderate shear strength. | Generally affected by seepage from canals or laterals; subsurface drainage difficult. | Moderate permeability; salinity. |
| Stony and cobbly, especially in the subsoil. | Good stability | Stony soils; moderate permeability. | Good shear strength; moderate permeability. | Sloping areas above irrigation canals; drainage not needed. | Not suitable for irrigation. |

TABLE 4.—*Interpretation of engineering properties*

| Soil series and map symbols | Suitability as a source of— | | | | Suitability for winter grading | Suscepti-bility to frost action |
|---|---|---|---|---|---|---|
| | Topsoil | Sand | Gravel | Road fill | | |
| Killpack (KlB, KlC2, KmB, KpB, KpC2). | Fair | Not suitable | Not suitable | Fair | Fair | Moderate |
| Libbings (Lb, Ls) | Not suitable | Not suitable | Not suitable | Fair | Poor | Moderate; too salty to freeze. |
| Minchey (McB, MlB, MsB, MsC2) (For interpretations of the Sanpete soils in MsB, and MsC2, refer to the Sanpete series.) | Fair to good | Not suitable | Subsoil fair for road gravel. | Very good | Good | Moderate |
| Mixed alluvial land (Mx) | Fair | Some fine sand in places. | Generally not suitable. | Fair | Moderate | Moderate |
| Palisade (PdB, PdC2) | Fair | Not suitable | Subsoil fair for road gravel. | Good | Good | High |
| Palisade variant (PaB) | Fair to good | Not suitable | Subsoil fair for road gravel. | Good | Poor to fair. | High |
| Penoyer (PeB, PeC2, PhD, PnA, PoB, PrA, PsB, PsC2, PvB2). | Good | Not suitable | Not suitable | Fair | Fair | High |
| Persayo (PCE2) (For interpretations of the Chipeta soil in this mapping unit, refer to the Chipeta series.) | Poor | Not suitable | Not suitable | Fair | Fair | Moderate |
| Rafael (Ra) | Fair | Not suitable | Not suitable | Fair | Poor | Moderate |
| Ravola (RlB, RlB2, RlC2, RnD, RsA, RsB, RtB, RuB2). (For interpretations of the Bunderson soil in RuB2, refer to the Bunderson series.) | Fair | Not suitable | Not suitable | Fair | Fair | High |
| Riverwash (Rv) | Poor | Some fine sand. | Has some suitable crushing material. | Poor | Good | Low |
| Saltair (Sa, Sb) | Not suitable | Not suitable | Not suitable | Fair | Poor | Moderate; too salty to freeze. |
| Sanpete (SlB, SlD2, SmD2) (For interpretations of the Minchey soil in SmD2, refer to the Minchey series.) | Poor; contains gravel and cobblestones. | Fair in places | Subsoil fair for road gravel. | Good | Good | Low |
| Shaly colluvial land (Sn) | Poor | Poor | Suitable for road gravel if crushed. | Good | Good | Low |
| Stony alluvial land (St) | Poor | Not suitable | Has suitable crushing rock for gravel. | Good | Good | Low |
| Woodrow (Wo) | Fair | Not suitable | Not suitable | Good | Fair | Moderate |

*of soils in the Carbon-Emery Area, Utah*—Continued

| Soil features affecting suitability for— | | | | | |
|---|---|---|---|---|---|
| Highway location | Dikes or levees | Farm ponds | | Agricultural drainage | Irrigation |
| | | Reservoir area | Embankment | | |
| Shale bedrock at depth of 20 to 40 inches. | Fair stability | Moderately slow permeability. | Moderate shear strength. | Gypsum layer is slowly permeable; top of shale serves as aquifer in many places. | Moderately slow permeability; moderately deep over shale. |
| High water table; severe salt. | Fair stability | Slow permeability. | Low shear strength. | Fine texture and adverse dip of bedrock make subsurface drainage difficult. | Very strong salinity; slow permeability; poor agricultural soil. |
| Good; gravelly or cobbly subsoil. | Good shear strength | Moderate permeability. | Good shear strength | Not needed | Moderate permeability. |
| Highly variable soil material; usually a water table. | Low to moderate shear strength. | Moderate to slow permeability. | Moderate shear strength. | Subsurface drainage difficult; variable soil material; lack of drainage outlets. | Moderate to slow permeability; fluctuating water table. |
| Gravel and cobblestones below 30 inches in places. | Good shear strength | Moderate permeability. | Good shear strength | Not needed | Moderate permeability. |
| Intermittent water table; subject to frost action. | Good shear strength. | Moderate permeability. | Good shear strength. | Gravelly, cobbly subsoil; suitable for subsurface drainage. | Seasonal high water table. |
| No limitations | Fair stability | Moderate permeability. | Moderate shear strength. | Not needed | Moderate permeability. |
| Poor foundation material; generally 8 to 20 inches of soil over shale. | Moderate shear strength. | Moderate permeability. | Moderate shear strength. | Not needed | Rolling hills; not well suited to irrigation. |
| High water table; subject to frost action. | Moderate shear strength. | Slow permeability | Moderate shear strength. | Subsurface drainage difficult; fine texture and adverse dip of bedrock. | High water table; salinity; irrigate only after drainage. |
| No limitations | Fair shear strength | Moderate permeability. | Fair shear strength | Subsurface drainage not needed. | Moderate permeability. |
| Flooding; sand, gravel, and cobblestones. | Flooding; sand, gravel, and cobblestones. | Sand, gravel, and cobblestones. | Sand, gravel, and cobblestones. | Not needed | Not suitable for irrigation. |
| High water table; very severely saline. | Fair shear strength | Slow permeability | Fair shear strength | Seasonal high water table; slow permeability; subsurface drainage difficult. | Very strong salinity. |
| Gravelly, cobbly subsoil. | Good stability | 10 to 20 inches deep over gravel and cobblestones. | Good shear strength; moderately rapid permeability. | Not needed | Low water-holding capacity; moderately rapid permeability. |
| Steep; shallow over shale bedrock. | Cobbly material; shallow over shale. | Shallow over shale | Cobbly and gravelly. | Steep; drainage not needed. | Not suitable for irrigation. |
| No limitations | High shear strength; rapid permeability. | Rapid permeability | High shear strength; rapid permeability. | Not needed | Stony; generally not suited to irrigation. |
| No limitations | Fair stability; susceptible to piping. | Slow permeability | Fair shear strength; subject to piping. | Slow permeability; subsurface drainage is satisfactory. | Slow permeability. |

335-819—70——3

TABLE 5.—*Engineering*

[Tests were performed by the Bureau of Public Roads in accordance with standard

| Soil and location | Parent material | Bureau of Public Roads report No. | Depth | Weight per cubic foot (air dry) |
|---|---|---|---|---|
| | | | *Inches* | *Pounds* |
| Billings silty clay loam: Sec. 31, T. 21 S., R. 7 E.; 1.3 miles SW. of Moore | Alluvium from shale. | S35191 | 0–28 | 98.00 |
| | | S35192 | 28–72 | |
| Sec. 22, T. 20 S., R. 7 E.; 2 miles S. of Ferron | Alluvium from shale. | S35193 | 0–32 | |
| | | S35194 | 32–59 | |
| Sec. 32, T. 22 S., R. 6 E.; 3.5 miles S. of Emery | Alluvium from shale. | S35213 | 0–10 | |
| | | S35214 | 10–60 | |
| Chipeta silty clay loam: Sec. 11, T. 19 S., R. 8 E.; 2 miles SE. of Castle Dale | Shale. | S35197 | 0–13 | 100.45 |
| | | S35198 | 13–17 | |
| Sec. 16, T. 17 S., R. 9 E.; 3.5 miles W. of Cleveland | Shale. | S35199 | 0–8 | |
| | | S35200 | 8 | |
| Ferron silt loam: Sec. 6, T. 19 S., R. 8 E.; 2.5 miles S. of Orangeville | Alluvium from shale. | S35201 | 0–24 | 107.95 |
| | | S35202 | 24–60 | |
| Killpack clay loam: Sec. 30, T. 16 S., R. 10 E.; 2 miles NW. of Elmo | Shale. | S35208 | 0–23 | 99.80 |
| | | S35209 | 23–29 | |
| Sec. 20, T. 21 S., R. 7 E.; one-eighth mile N. of Moore schoolhouse | Shale. | S35210 | 0–18 | |
| | | S35211 | 18–33 | |
| | | S35212 | 33 50 | |
| Minchey clay loam: Sec. 10, T. 20 S., R. 7 E.; one-eighth mile NE. of Ferron | Sandstone and quartzite. | S35215 | 0–10 | 92.35 |
| | | S35216 | 16–45 | |
| | | S35217 | 45–60 | |
| Minchey loam: Sec. 9, T. 17 S., R. 9 E.; 4 miles W. of Cleveland. (Nongravelly substratum.) | Sandstone and quartzite. | S35221 | 0–5 | 93.60 |
| | | S35222 | 15–26 | |
| | | S35223 | 26–30 | |
| Palisade very fine sandy loam: Sec. 20, T. 22 S., R. 6 E.; 3 miles S. of Emery | Sandstone and quartzite. | S35224 | 0–23 | 99.84 |
| | | S35225 | 23–41 | |
| | | S35226 | 41–60 | |
| Penoyer loam: Sec. 14, T. 20 S., R. 7 E.; 2 miles E. of Ferron | Alluvium from shale. | S35206 | 0–19 | |
| | | S35207 | 19–52 | |
| Persayo loam: Sec. 26, T. 17 S., R. 9 E.; 4 miles SW. of Cleveland | Shale. | S35195 | 0–3 | |
| | | S35196 | 3–8 | |
| Rafael silty clay loam: Sec. 29, T. 22 S., R. 6 E.; 3.5 miles S. of Emery | Alluvium from shale. | S35230 | 0–11 | |
| | | S35231 | 11–17 | |
| Ravola loam: Sec. 17, T. 21 S., R. 7 E.; 2.5 miles N. of Moore | Alluvium from shale. | S35232 | 0–14 | 94.85 |
| | | S35233 | 14–69 | 99.84 |
| Sec. 31, T. 16 S., R. 10 E.; 3 miles N. and 1 mile E. of Cleveland | Alluvium from shale. | S35234 | 0–19 | |
| | | S35235 | 19–60 | |

See footnotes at end of table.

*test data*

procedures of the American Association of State Highway Officials (AASHO) (*1*)]

| Mechanical analysis [1]— | | | | | | | | | | | | Liquid limit | Plasticity index | Classification | | Total soluble salt (1:2 dilution) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percentage passing sieve [2]— | | | | | | | | Percentage smaller than [2]— | | | | | | AASHO [3] | Unified [4] | |
| 1½-inch | 1-inch | ¾-inch | ⅜-inch | No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No. 40 (0.42 mm.) | No. 200 (0.074 mm.) | 0.05 mm. | 0.02 mm. | 0.005 mm. | 0.002 mm. | | | | | Percent |
| | | | | | 100 | 99 | 91 | 85 | 66 | 49 | 38 | 34 | 14 | A–6(10) | CL | 0. 29–0. 66 |
| | | | | | | | 96 | 91 | 70 | 50 | 38 | 36 | 16 | A–6(10) | CL | 0. 35–0. 41 |
| | | | | | | | 95 | 87 | 60 | 37 | 29 | 30 | 12 | A–6(9) | CL | 0. 25–0. 32 |
| | | | | | | | 92 | 76 | 49 | 30 | 24 | 26 | 9 | A–4(8) | CL | 0. 36–0. 60 |
| | | | | | 100 | 99 | 91 | 79 | 56 | 40 | 32 | 30 | 13 | A–6(9) | CL | 0. 30–0. 70 |
| | | | | | | | 94 | 80 | 53 | 36 | 29 | 29 | 11 | A–6(8) | CL | 0. 40–0. 80 |
| | | | | | | | 96 | 91 | 72 | 53 | 41 | 43 | 19 | A–7–6(12) | CL | 0. 22–0. 32 |
| | | | | | 100 | 99 | 95 | 91 | 75 | 56 | 42 | 44 | 19 | A–7–6(12) | ML–CL | 0. 29–0. 35 |
| | | | | | 100 | 98 | 92 | 89 | 71 | 48 | 37 | 36 | 15 | A–6(10) | CL | |
| | | | | | 100 | 99 | 97 | 95 | 79 | 52 | 36 | 41 | 19 | A–7–6(12) | CL | |
| | | | | | | | 82 | 65 | 41 | 28 | 23 | 27 | 8 | A–4(8) | CL | 0. 72 |
| | | | | | | | 91 | 77 | 52 | 35 | 27 | 29 | 11 | A–6(8) | CL | 0. 17–0. 23 |
| | | | | | 100 | 98 | 74 | 64 | 42 | 25 | 20 | 25 | 7 | A–4(8) | ML–CL | 0. 08–0. 1 |
| | | | | | | 100 | 90 | 86 | 58 | 42 | 32 | 34 | 15 | A–6(10) | CL | 0. 20 |
| | | | | | | | 93 | 82 | 61 | 44 | 36 | 38 | 21 | A–6(12) | CL | 0. 22–0. 33 |
| | | | | | 100 | 98 | 93 | 91 | 82 | 63 | 46 | 52 | 22 | A–7–5(15) | MH–CH | 1. 94–2. 31 |
| | | | | | 100 | 99 | 96 | 95 | 87 | 65 | 45 | 52 | 26 | A–7–6(17) | CH | 1. 06 |
| | | 100 | 98 | 97 | 96 | 94 | 76 | 68 | 53 | 42 | 34 | 38 | 17 | A–6(11) | CL | 0. 07 |
| | | | | | 100 | 99 | 77 | 59 | 40 | 29 | 25 | 24 | 7 | A–4(8) | ML–CL | 0. 05 |
| 4 | 89 | 82 | 69 | 61 | 54 | 49 | 37 | 32 | 24 | 18 | 11 | 20 | 6 | A–4(0) | GM–GC | 0. 09 |
| | | | 100 | 99 | 98 | 95 | 58 | 46 | 28 | 22 | 18 | 28 | 4 | A–4(5) | ML–CL | 0. 05 |
| | | | | | 100 | 99 | 83 | 71 | 52 | 38 | 31 | 29 | 12 | A–6(9) | CL | 0. 72 |
| | | | | | | | 94 | 87 | 61 | 37 | 28 | 29 | 11 | A–6(8) | CL | 0. 35 |
| | 99 | 98 | 94 | 89 | 86 | 81 | 51 | 40 | 29 | 23 | 18 | 25 | 7 | A–4(3) | ML–CL | 0. 13 |
| | | 100 | 98 | 96 | 94 | 90 | 52 | 41 | 32 | 26 | 21 | 24 | 6 | A–4(3) | ML–CL | 0. 02 |
| | 99 | 98 | 95 | 92 | 88 | 83 | 40 | 29 | 18 | 13 | 11 | [5] NP | NP | A–4(1) | SM | 0. 02 |
| | | | | | | 100 | 76 | 61 | 43 | 30 | 24 | 30 | 12 | A–6(9) | CL | 0. 05–0. 07 |
| | 99 | 99 | 98 | 98 | 98 | 97 | 76 | 59 | 37 | 24 | 19 | 22 | 5 | A–4(8) | ML–CL | 0. 03–0. 05 |
| | | | | | 100 | 99 | 93 | 82 | 55 | 37 | 27 | 28 | 9 | A–4(8) | CL | 0. 09–0. 13 |
| | | | | | 100 | 99 | 92 | 83 | 56 | 38 | 26 | 33 | 12 | A–6(9) | CL | 0. 11–0. 12 |
| | | | | | 100 | 99 | 81 | 71 | 49 | 34 | 27 | 28 | 10 | A–4(8) | CL | 0. 31–0. 59 |
| | | | | | 100 | 99 | 83 | 73 | 50 | 35 | 27 | 29 | 12 | A–6(9) | CL | 0. 39–1. 02 |
| | | | | | | | 84 | 66 | 41 | 25 | 19 | 24 | 6 | A–4(8) | ML–CL | |
| | | | | | 100 | 98 | 68 | 50 | 25 | 18 | 14 | 22 | 2 | A–4(7) | ML | |
| | | | | | 100 | 99 | 81 | 64 | 40 | 29 | 23 | 26 | 9 | A–4(8) | ML–CL | 0. 05–0. 08 |
| | | | | | | | 95 | 85 | 55 | 37 | 29 | 28 | 10 | A–4(8) | CL | 0. 04–0. 07 |

TABLE 5.—*Engineering*

| Soil and location | Parent material | Bureau of Public Roads report No. | Depth | Weight per cubic foot (air dry) |
|---|---|---|---|---|
| | | | *Inches* | *Pounds* |
| Saltair silty clay loam: | | | | |
| Sec. 25, T. 17 S., R. 8 E.; 1 mile SW. of Huntington | Alluvium from shale. | S35236 | 0–10 | ---------- |
| | | S35237 | 10–60 | ---------- |
| Sanpete sandy clay loam: | | | | |
| Sec. 30, T. 22 S., R. 6 E.; 1.5 miles SW. of Emery | Sandstone and quartzite. | S35203 | 3–12 | 106. 00 |
| | | S35204 | 12–20 | ---------- |
| | | S35205 | 26 | ---------- |

[1] Mechanical analysis according to AASHO Designation T 88–57 (*1*). Results by this procedure may differ from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

### *Engineering classification systems*

Two systems of classifying soils are in general use among engineers. In table 3 the estimated classifications of the soils are given, according to both systems.

*AASHO Classification System*—The American Association of State Highway Officials system (*1*) of classifying soils is an engineering-property classification based on field performance of highways. It is the most widely known system used in highway practice. Under this system, grouping soils of about the same general load-carrying capacity and service characteristics resulted in seven basic groups that were designated A–1 through A–7. The best soils for road subgrades are classified as A–1, and the poorest soils are classified as A–7.

*Unified Soil Classification System.*—The Unified Soil Classification System (*10*) is based on the soil classification system developed by Dr. Arthur Casagrande, of Harvard University, for the Corps of Engineers during World War II. The original classification has been revised and expanded in cooperation with the U.S. Bureau of Reclamation so that it now applies to embankments and foundations as well as to roads and airfields. It is used by the Corps of Engineers, Bureau of Reclamation, and the Soil Conservation Service.

In the Unified system, soils are identified according to their texture and plasticity and are grouped according to their performance as engineering construction material. Soil materials are classified as coarse grained, which are gravels (G) and sands (S); fine grained, which are silts (M) and clays (C); and highly organic (O). In this system clean sands are identified by the symbols SW and SP; sands with fines of silt and clay, by SM and SC; silts and clays having low liquid limit, by ML and CL; and silts and clays having high liquid limit, by MH and CH.

### *Estimated engineering properties and interpretations of soils*

Since laboratory tests were made for only a few soils in the county, it was necessary to infer the engineering properties of other soils mapped by comparing those soils with the ones analyzed in the laboratory and by studying the soils in the field. Results of these comparisons and studies are given in tables 3 and 4. The estimates given in tables 3 and 4 provide much information useful to engineers. They are not a suitable substitute, however, for the detailed tests needed at a site selected for construction.

In addition to this subsection, the sections "Descriptions of the Soils," "Formation and Classification of Soils," and other parts of the soil survey are useful to engineers. Some of the terms used by soil scientists may be unfamiliar to engineers. Other terms may be familiar to engineers but not familiar to other persons who use this survey. Many of these terms used in describing the soils and their use and management are defined in the Glossary near the back of the soil survey.

The terms "silt" and "clay," as used in the engineering classification of soils are different from those used by soil scientists. They are terms used by soil scientists to indicate textural classes of soils. Engineers, on the other hand, use the terms "silty" or "clayey" to refer to the plasticity index of a soil. The term "silty" is applied to fine material that has a plasticity index of 10 or less. The term "clayey" is applied to fine material that has a plasticity index of more than 10.

The meaning of the hydrologic groupings shown in table 3 may be unfamiliar to some persons who use this soil survey. In group A are soils that have the highest

*test data*—Continued

| Mechanical analysis [1]— | | | | | | | | | | | | Liquid limit | Plasticity index | Classification | | Total soluble salt (1:2 dilution) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percentage passing sieve [2]— | | | | | | | | Percentage smaller than [2]— | | | | | | | | |
| 1½-inch | 1-inch | ¾-inch | ⅜-inch | No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No. 40 (0.42 mm.) | No. 200 (0.074 mm.) | 0.05 mm. | 0.02 mm. | 0.005 mm. | 0.002 mm. | | | AASHO [3] | Unified [4] | |
| | | | | | | | | | | | | | | | | *Percent* |
| ----- | ----- | ----- | ----- | ----- | ----- | ----- | 92 | 76 | 49 | 29 | 23 | 25 | 8 | A-4(8) | CL | 2. 10 |
| ----- | ----- | ----- | ----- | ----- | ----- | ----- | 86 | 72 | 44 | 25 | 20 | 23 | 5 | A-4(8) | ML-CL | 2. 35 |
| ----- | ----- | 100 | 99 | 97 | 96 | 93 | 55 | 39 | 28 | 22 | 19 | 21 | 4 | A-4(4) | ML-CL | 0. 02 |
| ([6]) | ----- | 80 | 79 | 78 | 78 | 73 | 45 | 38 | 26 | 22 | 18 | 23 | 5 | A-4(4) | ML-CL | 0. 02 |
| 20 | 79 | 79 | 78 | 77 | 74 | 69 | 28 | 21 | 14 | 10 | 7 | NP | NP | A-2-4(0) | SM | 0. 04-0. 24 |

[2] Based on total material; laboratory test data were corrected for amount discarded in sampling.
[3] Based on AASHO Designation M 145-49 (*1*).
[4] Based on the Unified Soil Classification System, Tech. Memo. No. 3-357, v. 1, Corps of Engineers (*10*). SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of the A-line are to be given a borderline classification. An example of a borderline classification is ML-CL.
[5] NP=Nonplastic.
[6] Discarded in field sampling; larger than 10 inches.

rate of infiltration, even when they are thoroughly wet, and the lowest runoff potential. These soils are deep sands or gravelly soils. In group B are soils that may be shallower or contain more clay than those in group A. Soils in group B have a moderate rate of infiltration and moderate runoff potential. In group C are soils that are shallow over an impermeable layer or that contain considerable clay and colloids. These soils have a slow rate of infiltration and high runoff potential. In group D are mainly clayey soils that have high swelling potential or soils that are shallow over nearly impervious material or that contain a clayey layer. The soils in group D have a very slow rate of infiltration and very high runoff potential.

### *Soil test data*

Samples from the most representative soil types in the Carbon-Emery Area, Utah, were tested by the Bureau of Public Roads so that the soils could be evaluated for engineering purposes. These test data are given in table 5. The test data show the characteristics of the soil at a specified location.

The engineering classifications given in table 5 are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits (Atterburg limits). Mechanical analyses were made by combined sieve and hydrometer methods.

The tests to determine plastic limit and liquid limit measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic state to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which the soil material is in a plastic condition.

## *Descriptions of the Soils*

This section describes the soil series, which are groups of similar soils, and the single soils, or mapping units, of the Carbon-Emery Area. The acreage and proportionate extent of each mapping unit are given in table 6.

The procedure in this section is first to describe the soil series and then the mapping units in the series. Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Badland, Gullied land, Mixed alluvial land, Riverwash, Rock land, Shaly colluvial land; and Stony alluvial land are all miscellaneous land types and do not belong to a soil series; nevertheless, they are listed in alphabetic order along with the series.

The mapping units in this survey are not all of equal intensity, or degree of precision. Mapping units in parts of the survey area that are cultivated, or mostly cultivated, contain less than 20 percent of soils other than those shown in the name of the unit.

In the tracts not cultivated, a mapping unit having slopes of less than 3 percent includes few areas of other

soils, unless it is a unit that occurs where deep soils are adjacent to moderately deep or shallow soils. Some eroded mapping units, and those mapping units having slopes of 3 to 30 percent, include more than 20 percent of soils other than those shown in the names of the units. Also, boundaries of some of these eroded or wide-slope-range mapping units are less precise.

Unless stated otherwise, the colors shown in this section are those of a dry soil. Color designations are those of the Munsell system.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit and range site in which the mapping unit has been placed. The page on which each capability unit and each range site is described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

Soil scientists, engineers, students, and others interested in the origin and classification of the soils should turn to the section "Formation and Classification of Soils." Many terms used in the soil descriptions and other sections are defined in the Glossary and in the "Soil Survey Manual" (7).

Many soils in the survey area contain at least small quantities of soluble salts or alkali, or both. In some soils

TABLE 6.—*Approximate acreage and proportionate extent of each mapping unit*

| Mapping unit | Acres | Percent |
|---|---|---|
| Abbott silty clay | 215 | (1) |
| Abbott silty clay, strongly saline | 496 | 0.1 |
| Badland | 16,638 | 3.4 |
| Beebe loam, 1 to 3 percent slopes | 238 | (1) |
| Beebe loamy fine sand, 1 to 3 percent slopes | 1,379 | .3 |
| Beebe loamy fine sand, 3 to 6 percent slopes, eroded | 313 | .1 |
| Beebe loamy fine sand, extended season, 0 to 1 percent slopes | 916 | .2 |
| Billings silty clay loam, 1 to 3 percent slopes | 20,787 | 4.3 |
| Billings silty clay loam, 1 to 6 percent slopes, eroded | 2,480 | .5 |
| Billings silty clay loam, deep watertable, 1 to 3 percent slopes | 939 | .2 |
| Billings silty clay loam, extended season, 1 to 3 percent slopes | 479 | .1 |
| Billings-Bunderson complex, 1 to 3 percent slopes, eroded | 836 | .2 |
| Cache silty clay | 771 | .2 |
| Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded | 22,648 | 4.8 |
| Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded | 6,346 | 1.3 |
| Chipeta-Badland association, 3 to 30 percent slopes, eroded | 51,318 | 10.7 |
| Chipeta-Persayo association, 1 to 3 percent slopes | 10,913 | 2.3 |
| Chipeta-Persayo association, 3 to 20 percent slopes, eroded | 3,239 | .7 |
| Ferron silty clay loam, heavy variant | 346 | .1 |
| Ferron silt loam | 1,169 | .2 |
| Green River loam | 729 | .1 |
| Gullied land | 11,232 | 2.3 |
| Harding very fine sandy loam | 376 | .1 |
| Hunting loam | 5,096 | 1.1 |
| Hunting loam, moderately saline | 5,012 | 1.1 |
| Hunting silty clay loam | 298 | .1 |
| Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded | 18,958 | 4.0 |
| Killpack clay loam, 1 to 3 percent slopes | 8,543 | 1.8 |
| Killpack clay loam, 3 to 6 percent slopes, eroded | 1,943 | .4 |
| Killpack clay loam, high watertable variant, 1 to 3 percent slopes | 421 | .1 |
| Killpack loam, 1 to 3 percent slopes | 927 | .2 |
| Killpack loam, 3 to 6 percent slopes, eroded | 1,302 | .3 |
| Libbings silty clay loam | 4,986 | 1.4 |
| Libbings silty clay loam, barren | 800 | .2 |
| Minchey clay loam, 1 to 3 percent slopes | 348 | .1 |
| Minchey loam, 1 to 3 percent slopes | 1,553 | .3 |
| Minchey-Sanpete complex, 1 to 3 percent slopes | 3,681 | .8 |
| Minchey-Sanpete complex, 1 to 6 percent slopes, eroded | 5,582 | 1.2 |
| Mixed alluvial land | 7,954 | 1.7 |
| Palisade loam, high watertable variant, 1 to 3 percent slopes | 187 | (1) |
| Palisade very fine sandy loam, 1 to 3 percent slopes | 3,479 | .7 |
| Palisade very fine sandy loam, 3 to 6 percent slopes, eroded | 1,690 | .4 |
| Penoyer loam, 1 to 3 percent slopes | 7,774 | 1.6 |
| Penoyer loam, 3 to 6 percent slopes, eroded | 1,036 | .2 |
| Penoyer loam, 1 to 10 percent slopes, channeled | 73 | (1) |
| Penoyer loam, extended season, 0 to 1 percent slopes | 876 | .2 |
| Penoyer silty clay loam, 1 to 3 percent slopes | 648 | .1 |
| Penoyer silty clay loam, extended season, 0 to 1 percent slopes | 454 | .1 |
| Penoyer very fine sandy loam, 1 to 3 percent slopes | 1,441 | .3 |
| Penoyer very fine sandy loam, 3 to 6 percent slopes, eroded | 5,366 | 1.1 |
| Penoyer very fine sandy loam, alkali, 1 to 3 percent slopes, eroded | 1,141 | .2 |
| Persayo-Chipeta association, 1 to 20 percent slopes, eroded | 42,242 | 8.9 |
| Rafael silty clay loam | 3,581 | .8 |
| Ravola loam, 1 to 3 percent slopes | 27,848 | 5.8 |
| Ravola loam, 1 to 3 percent slopes, eroded | 5,852 | 1.2 |
| Ravola loam, 3 to 6 percent slopes, eroded | 7,374 | 1.5 |
| Ravola loam, 1 to 10 percent slopes, channeled | 274 | .1 |
| Ravola loam, extended season, 0 to 1 percent slopes | 201 | (1) |
| Ravola loam, extended season, 1 to 3 percent slopes | 143 | (1) |
| Ravola silty clay loam, 1 to 3 percent slopes | 6,717 | 1.4 |
| Ravola-Bunderson complex, 1 to 3 percent slopes, eroded | 7,855 | 1.6 |
| Riverwash | 3,733 | .8 |
| Rock land | 58,984 | 12.5 |
| Saltair silty clay loam | 14,135 | 3.0 |
| Saltair silty clay loam, barren | 788 | .2 |
| Sanpete sandy clay loam, 1 to 3 percent slopes | 2,403 | .5 |
| Sanpete sandy clay loam, 3 to 10 percent slopes, eroded | 6,048 | 1.3 |
| Sanpete-Minchey complex, 1 to 10 percent slopes, eroded | 1,662 | .3 |
| Shaly colluvial land | 38,272 | 7.8 |
| Stony alluvial land | 1,661 | .4 |
| Woodrow silty clay loam | 2,328 | .5 |
| Total | 478,473 | 100.0 |

1 Less than 0.05 percent.

the concentration of salts and alkali is moderate to strong. Much of the salts and alkali originates from the extensive salt- and gypsum-bearing shale in the area. When the shale weathers, these salts are released and remain in the soil as soluble materials because evaporation is high and the inadequate rainfall does not wash them out. In addition, many low areas receive salty runoff or seepage water from surrounding areas. When the water evaporates, the salts remain.

If the proportion of sodium salts in a soil is high in relation to the content of calcium and magnesium salts, an exchange of the sodium for calcium or magnesium occurs on the surface of the clay particles. Soils that have a high proportion of this exchanged sodium disperse on wetting, which materially reduces pore space, permeability, and aeration. A soil that has 15 percent or more of exchangeable sodium is called an alkali soil. A soil that contains excessive soluble salts but no alkali is referred to as a saline soil. If an excess of soluble salts and an excess of alkali occur together, the soil is called saline-alkali.

Where the salt or alkali content of a soil ranges from none to strong, the affected areas are shown on the map as separate units, and they are designated as moderately or strongly saline or alkali.

## Abbott Series

The Abbott series consists of poorly drained, deep, gently sloping soils that are fine textured and moderately to strongly saline. These soils are on the lower parts of alluvial fans and on the flood plains of streams, where they have formed in alluvium derived from shale. The native vegetation is mainly sedges and wiregrass. Elevations range from 5,000 to 6,500 feet. The annual rainfall ranges from 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season ranges from 110 to 130 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous, very hard silty clay about 14 inches thick. The underlying material is light brownish-gray silty clay or clay to a depth of about 36 inches. Below that depth is light olive-gray and light-gray silty clay loam. Mottling or gleying above a depth of 20 inches is typical.

These soils have a high water table during most of the year. The water table is only a few inches beneath the surface a large part of the time, but in some seasons it is as much as 40 inches beneath the surface.

Abbott soils are used for wet meadow pasture.

Representative profile of Abbott silty clay in a wet meadow pasture, 2,150 feet south and 700 feet east of the NW. corner of section 14, T. 20 S., R. 7 E., in Emery County, Utah:

O1—1½ inches to 0, organic material that is mainly grass roots; strongly calcareous; neutral (pH 7.1); clear, smooth boundary.

A11—0 to 6 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; weak, medium, granular structure; very hard, very firm, sticky and plastic; many medium and fine roots; few medium pores; strongly calcareous; neutral (pH 7.1); clear, wavy boundary.

A12—6 to 14 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; common, medium, prominent, yellowish-red (5YR 5/6) mottles; weak, fine, angular blocky structure; very hard, very firm, sticky and plastic; few medium and many fine roots; few medium and fine pores; strongly calcareous; neutral (pH 7.3); clear, wavy boundary.

C1—14 to 21 inches, light brownish-gray (2.5Y 6/2) silty clay, dark gray (5Y 4/1) when moist; common, medium, distinct, strong-brown (7.5YR 5/8) mottles; weak, medium to fine, angular blocky structure; very hard, very firm, sticky and plastic; few medium and common fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.6); clear, wavy boundary.

C2g—21 to 29 inches, light brownish-gray (2.5Y 6/2) clay, dark gray (5Y 4/1) when moist; common, medium, distinct, yellowish-brown (10YR 5/6) mottles and many, medium, faint, gray (N 5/0) mottles; weak, medium to fine, angular blocky structure; very hard, very firm, sticky and plastic; few medium and few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.6); clear, wavy boundary.

C3g—29 to 36 inches, light brownish-gray (2.5Y 6/2) silty clay, dark gray (5Y 4/1) when moist; many, medium, distinct, light olive-brown (2.5Y 5/6) mottles and few, medium, faint, gray (N 5/0) mottles; weak to moderate, medium to fine, angular blocky structure; very hard, very firm, sticky and plastic; few medium and few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); clear, wavy boundary.

C4g—36 to 45 inches, light olive-gray (5Y 6/2) silty clay loam, dark gray (5Y 4/1) when moist; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles and common, medium, faint, gray (N 5/0) mottles around root channels; massive; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; moderately alkaline (pH. 7.9); gradual, wavy boundary.

C5g—45 to 60 inches, light-gray (5Y 7/2) light silty clay loam, olive (5Y 5/3) when moist; common, medium, distinct, light olive-brown (2.5Y 5/6) mottles and common, medium, faint, gray (N 5/0) mottles around root channels; massive; hard, firm, sticky and plastic; few medium and fine roots; few fine pores; strongly calcareous; moderately alkaline (pH. 7.9).

Salinity ranges from moderate to strong. The content of lime ranges from 5 to 35 percent. The A1 horizons have a dominant hue of 2.5Y, but the hue ranges from 2.5Y to 5Y. Value in these horizons is 5 or 6 when the soils are dry and 4 or 5 when they are moist; chroma is 1 or 2. At a depth of 20 inches or less, the soils have chroma of 1, or mottles, or both. The part of the profile between depths of 10 and 40 inches is silty clay loam to clay and contains more than 35 percent clay. The color of the upper 40 inches is about the same. Below a depth of 40 inches, the texture ranges from sandy loam to clay; hue ranges from 2.5Y to 5Y; value is 6 or 7 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 1 to 3.

**Abbott silty clay** (1 to 3 percent slopes) (Ab).—The profile of this soil is the one described as typical of the series. The thickness of the layer that contains a large amount of organic matter, however, ranges from 1 to 4 inches. In most places this soil is mottled to the surface. Gleying is more intense below a depth of 36 inches than higher in the profile. Depth to the water table ranges from 6 to 40 inches. Typically, the water table is highest in May and June, but it fluctuates with differences in the seasons. The clayey texture of this soil makes draining and reclamation difficult.

Included with this soil in mapping were small areas of Ferron silt loam and of Rafael silty clay loam. Also included were some spots that are strongly saline.

Drainage is poor, and permeability and the rate of infiltration are slow. Roots penetrate to a depth of 5 feet but are concentrated above a depth of 30 inches. The soil retains 8 to 10 inches of water, but only about 4.5 inches is readily available to plants. The amount of moisture readily available to plants is reduced, to some extent, by the large amount of salts in the soil. Runoff is slow, and the hazard of erosion is slight. Salinity is moderate, and workability is poor.

Grazing is the main use of this soil. In places, however, one cutting of grass hay is also obtained each year in addition to the forage grazed. Response to a nitrogen or phosphate fertilizer is generally good. (Capability unit VIw–2, nonirrigated; Wet Meadow range site)

**Abbott silty clay, strongly saline** (1 to 3 percent slopes) (As)—The profile of this soil is similar to the one described for the series, except that it is strongly saline. The salt that has accumulated increases the difficulty of reclaiming this soil after the areas have been drained.

Included with this soil in mapping were minor areas of a soil that is bare and that has salt crusted on the surface. Also included were small spots of soils that have a surface layer of loam or heavy loam.

Grazing is the main use of this Abbott soil. The vegetation is mostly saltgrass and alkali sacaton. (Capability unit VIIw–28, nonirrigated; Salt Meadow range site)

**Badland** (Ba) consists of nearly bare, strongly sloping to very steep, actively eroding shale; of areas of shale interbedded with sandstone; and of occasional small sandstone-capped hills (fig. 10). The channels of numerous intermittent streams form a branching pattern in most places. Mapped with Badland are minor inclusions of shallow soils, especially in the drainageways.

Badland is in the Mancos geologic formation throughout most of the survey area, but it is in the Cedar Mountain formation along the eastern edge. (Capability unit VIIIs–7, nonirrigated; not rated for other uses)

***Figure 10.*—Badland consisting of nearly bare, actively eroding shale hills.**

## Beebe Series

The Beebe series consists of deep, well-drained, coarse-textured soils that are strongly affected by alkali unless they are cultivated and irrigated. These soils are on alluvial fans and flood plains, where they have formed in alluvium derived from mixed sedimentary rocks. The present vegetation is dominantly greasewood, rabbitbrush, and in some places big sage. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season ranges from 110 to 160 days.

In a typical profile, the surface layer is pale-brown, slightly calcareous very fine sandy loam about 2 inches thick. The underlying material is light yellowish-brown loamy fine sand that is weakly stratified with layers of loam or fine sand.

Many areas of the Beebe soils are still in range. Crops grown on irrigated areas are alfalfa, small grains, corn, and sugar beets. Some areas are also used for irrigated pasture.

Representative profile of a Beebe loamy fine sand in a range area, 260 feet south and 10 feet west of the NW. corner of section 7, T. 22 S., R. 7 E., in Emery County, Utah:

A1—0 to 2 inches, pale-brown (10YR 6/3) very fine sandy loam, brown (10YR 4/3) when moist; weak, medium and thick, platy structure; soft, very friable, nonsticky and nonplastic; few medium and many fine roots; common medium and fine pores; slightly calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

IIC1—2 to 12 inches, light yellowish-brown (10YR 6/4) loamy fine sand, yellowish brown (10YR 5/4) when moist; weak, thick, platy structure; soft, very friable, nonsticky and nonplastic; few large, plentiful very fine, and few medium roots; few medium and fine pores; slightly calcareous; very strongly alkaline (pH 9.7); clear, smooth boundary.

IIIC2—12 to 16 inches, light yellowish-brown (10YR 6/4) fine sand, yellowish brown (10YR 5/4) when moist; single grain; loose, nonsticky and nonplastic; plentiful fine roots; interstitial pores; slightly calcareous; very strongly alkaline (pH 9.6); clear, wavy boundary.

IVC3—16 to 34 inches, light yellowish-brown (10YR 6/4) loamy fine sand, yellowish brown (10YR 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; plentiful, fine and medium roots; few medium and fine pores; slightly calcareous; strongly alkaline (pH 8.5); clear, smooth boundary.

VC4—34 to 39 inches, light yellowish-brown (10YR 6/4) loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few medium and plentiful fine roots; few medium and common fine pores; slightly calcareous; moderately alkaline (pH 7.9); clear, smooth boundary.

VIC5—39 to 71 inches, light yellowish-brown (10YR 6/4) loamy fine sand, yellowish brown (10YR 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; plentiful fine and medium roots; few fine pores; slightly calcareous; moderately alkaline (pH 8.2).

Exchangeable sodium ranges from 20 to 70 percent within 20 inches of the surface in nonirrigated areas of these soils. The content of lime ranges from 3 to 20 percent. The reaction is mildly to very strongly alkaline. Unless irrigated, the soils are usually dry when not frozen. In the A1 horizon, hue ranges from 10YR to 7.5YR; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 2 to 4. In some places the A1 horizon has been

silted by irrigation water. The part of the profile between 10 and 40 inches ranges from fine sand to loam, but generally it is loamy fine sand. In this part hue ranges from 10YR to 7.5YR; value is 6 or 7 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 3 to 5.

**Beebe loam, 1 to 3 percent slopes** (BbB).—This soil has a loam surface layer 6 to 12 inches thick. Below a depth of 12 inches, its profile is like the one described as typical for the series. The surface layer retains about 3 inches of water readily available to plants, and it is moderately susceptible to erosion.

Included with this soil in mapping were minor areas of loamy fine sand. Also included were soils that have slopes of 3 to 6 percent, which occupy about 60 acres on the bench south of Lawrence.

This Beebe soil is easy to work and to irrigate, but leveling is needed to obtain uniform distribution of water. Crops grown under irrigation are alfalfa, small grains, corn for ensilage, pasture plants, and sugar beets. Corn is not grown on the included soils that have slopes of 3 to 6 percent. Some areas are used for range. (Capability units IVs-26, irrigated, and VIIe-D6, nonirrigated; Desert Sandy Loam range site)

**Beebe loamy fine sand, 1 to 3 percent slopes** (BeB).—The profile of this soil is the one described as typical of the series. This soil normally has a texture of loamy fine sand throughout, but it contains interspersed layers, 2 to 6 inches thick, in which the texture is loam to sand. This soil is easy to work and to irrigate. If it is cultivated and irrigated, the salt and alkali leach out readily.

Included in mapping where this soil adjoins other soils were small areas that have a surface layer of loam or light loam.

This Beebe soil is well drained, and it is highly susceptible to wind erosion. Permeability is rapid, and runoff is slow. Roots penetrate deeply. The soil retains about 4 inches of available water, but only about 2 inches is readily available to plants.

Crops grown under irrigation are alfalfa, small grains, pasture plants, sugar beets, and small areas of corn. Alfalfa is well suited to this soil. It produces two crops and sometimes a small third crop. Because the growing season is short, corn does not mature for grain and is used only for ensilage. Many areas are still in range. Alfalfa responds to a phosphate fertilizer; small grains, corn, and pasture respond to a nitrogen fertilizer. (Capability units IVs-26, irrigated, and VIIe-D6, nonirrigated; Desert Sandy Loam range site)

**Beebe loamy fine sand, 3 to 6 percent slopes, eroded** (BeC2).—This sloping soil is on alluvial fans. Runoff is medium. Some shallow gullies and rills have formed, but most losses of soil material have been caused by sheet erosion.

Included in mapping were some areas that have a loamy surface layer and some areas of slightly eroded or noneroded soils.

Range is the dominant use of this Beebe soil; only a small acreage is cultivated. Crops grown under irrigation are mainly alfalfa, mixtures of alfalfa and grass, and small grains. (Capability units IVs-26, irrigated, and VIIe-D6, nonirrigated; Desert Sandy Loam range site)

**Beebe loamy fine sand, extended season, 0 to 1 percent slopes** (BfA).—This soil is near Green River. It is similar to Beebe loamy fine sand, 1 to 3 percent slopes, except that it is nearly level and occurs in areas where there is an extended growing season of 140 to 160 days. Many areas have been leveled to obtain uniform distribution of irrigation water. Land leveling causes little or no damage to the soil and is still needed in some places.

Included in mapping were some soils that have a loam surface layer 8 to 14 inches thick and slopes of 1 to 2 percent. Also included were areas on both sides of the river north of the town of Green River where wind has blown the soils into hummocks 1 to 3 feet high. In one small area, the soils in these hummocks have slopes of 3 to 6 percent. These hummocky soils must be leveled before they can be cultivated and irrigated.

Crops grown under irrigation are alfalfa, small grains, corn, melons, pasture plants, and sugar beets. The growing season is long enough for corn to mature and for alfalfa to yield three cuttings. (Capability units IIIs-16, irrigated, and VIIe-D6, nonirrigated; Desert Sandy Loam range site)

## Billings Series

The Billings series consists of soils that are moderately fine textured, calcareous, and well drained or moderately well drained. These soils are on alluvial fans, on flood plains, and in narrow alluvial valleys. They have formed in alluvium that washed from alkaline, gypsum-bearing marine shale. The vegetation is dominantly greasewood, shadscale, galletagrass, and Indian ricegrass. Elevations range from 4,000 to 6,500 feet. The annual rainfall ranges from 6 to 11 inches, and the frost-free season ranges from 110 to 160 days. The mean annual temperature of the soil ranges from 47° to 54° F.

In a typical profile, the surface layer is light brownish gray, strongly calcareous, hard silty clay loam about 11 inches thick. The underlying material is also light brownish-gray, mainly silty clay loam that is weakly stratified with thin layers of loam or clay loam. The profile contains crystals, veins, or soft nodules of gypsum at a depth below 20 inches.

Nearly all the acreage has been cleared and planted to irrigated crops, mainly alfalfa, small grains, corn, pasture plants, and sugar beets. Areas that have not been cleared are used for spring and fall range.

Representative profile of a Billings silty clay loam in a nearly salt-free cultivated field, 2,000 feet west and 600 feet north of the SE. corner of section 20, T. 17 S., R. 9 E., in Emery County, Utah:

Ap1—0 to 3 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, granular structure; hard, firm, sticky and plastic; plentiful medium roots; common medium pores; strongly calcareous; moderately alkaline (pH 7.9); clear, smooth boundary.

Ap2—3 to 11 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, angular and subangular blocky structure; hard, firm, sticky and plastic; plentiful medium roots; common fine pores; strongly calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

C1—11 to 18 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, angular and subangular blocky structure; hard, firm, sticky and plastic; few fine

roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.8); gradual, wavy boundary.

C2—18 to 42 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine, discontinuous pores; strongly calcareous; few soft gypsum nodules; mildly alkaline (pH 7.6); diffuse boundary.

C3—42 to 58 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; massive; hard, firm, sticky and plastic; few fine roots; few fine discontinuous pores; few, fine, light grayish-brown (10YR 6/2), soft gypsum nodules; strongly calcareous; moderately alkaline (pH 8.0).

Salinity and alkalinity range from slight to strong, and the content of lime ranges from 5 to 25 percent. The content of gypsum in the lower C horizon ranges from 0.5 to 25 percent; gypsum nodules and crystals occur in this horizon. Clay minerals are mixed but are mainly illite and kaolinite. Unless irrigated, the soils are generally dry when not frozen. Distinct mottles occur in the moderately well drained areas at depths below 36 inches. The A1 horizon has a hue of 2.5Y to 5Y. Value in this horizon is 6 or 7 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 2 to 4. The part of the profile between 10 and 40 inches is silty clay loam to clay loam and contains 27 to 35 percent clay and 15 percent sand that is coarser than very fine sand. The color of the upper 40 inches is similar to that of the A1 horizon.

Billings soils occur with the Bunderson soils.

**Billings silty clay loam, 1 to 3 percent slopes** (BlB).—This soil has the profile described as typical of the series. In some places the underlying material contains thin layers of loam or clay loam. Veins, crystals, or nodules of gypsum are common below a depth of 12 to 20 inches but occur erratically, depending on the source of sediment.

Included with this soil in mapping were spots, generally less than 2 acres in extent, that are strongly affected by salt and alkali. Also included were some loamy soils, small areas of clayey soils, and some places, especially below shaly colluvial slopes, where gravel is on the surface.

This Billings soil is well drained and is moderately susceptible to erosion. It retains about 11 inches of water, but only about 5 inches of water is readily available to plants. Runoff is medium, and permeability is slow. Roots penetrate deeply. The frost-free period is 110 to 130 days in 3 out of 4 years. Natural fertility is low, but fertility can be increased by applying manure and commercial fertilizer. This soil is fairly hard to work. The seedbed is more easily prepared if the soil is plowed in fall when it is moist, and is allowed to remain rough over winter, than when plowing is done in spring.

This soil is used for irrigated alfalfa, small grains, corn, pasture, and sugar beets. Alfalfa yields two crops and part of a third. Corn does not mature for grain and is used for ensilage or is pastured. Alfalfa generally responds to phosphate; small grains, corn, and pasture plants respond to a fertilizer containing nitrogen.

The soil generally needs to be leveled so that water can be distributed evenly. Leveling causes no damage if done when the soil is fairly dry. Many areas have already been leveled, and many areas of this soil are still in range. (Capability units IIIe–25, irrigated, and VIIs–D, nonirrigated; Desert Loam Bottom range site)

**Billings silty clay loam, 1 to 6 percent slopes, eroded** (BlC2).—This soil is on alluvial fans. In many places it is below nearly bare shale hills. Surface runoff from these shale hills is rapid and causes sheet and gully erosion. In some places runoff has broken through irrigation ditches or canals and has formed gullies.

Originally, this soil was similar to Billings silty clay loam, 1 to 3 percent slopes. It is now eroded and contains gullies 3 to 10 feet deep and 100 to 500 feet apart. Runoff is rapid, and the susceptibility to erosion is high. Because of the gullies, this soil is used mainly for spring and fall range. In a few places where gullies do not occur, this soil is used for irrigated alfalfa and grass. (Capability unit VIIe–D, nonirrigated; Desert Loam Bottom range site)

**Billings silty clay loam, deep watertable, 1 to 3 percent slopes** (BsB).—This moderately well drained, moderately saline soil generally occurs with other poorly drained, saline soils. It is similar to and occurs with Billings silty clay loam, 1 to 3 percent slopes, but it is lower on the slopes.

The water table fluctuates with the season, but generally it is 36 to 60 inches below the surface. The effects of this water table are evident from the generally spotty appearance of the surface, caused by the accumulation of salts and alkali. This soil typically is mottled at depths between 3 and 5 feet. Included in mapping were some areas, ranging from 1 to 3 acres in extent, that are very strongly affected by salts and alkali.

Adequate drainage is difficult to maintain in this soil. To control wetness, ditches and canals should be lined and overirrigation avoided. These practices are more effective than artificial drainage, and they also help to reduce losses of irrigation water. The soil retains about 12 inches of water, but only about 4.5 inches is readily available to plants. Salts in this soil reduce the amount of water available to plants.

Irrigated pasture is the main use of this soil. Alfalfa and grain crops are grown, but yields of these crops are poor and erratic. (Capability unit IVs 28, irrigated; not rated for other uses)

**Billings silty clay loam, extended season, 1 to 3 percent slopes** (BtB).—This soil is near Green River. Included in mapping were small areas of nearly level soils that appear spotty because salts and alkali have accumulated in the surface layer. The water table in these included areas is 30 to 60 inches below the surface.

Crops grown under irrigation are alfalfa, small grains, corn, cantaloups, pasture, and sugar beets. The growing season is 140 to 160 days. It is long enough for corn to mature for grain and for alfalfa to yield three full crops. (Capability unit IIIe–15, irrigated; not rated for other uses)

**Billings-Bunderson complex, 1 to 3 percent slopes, eroded** (BuB2).—The soils of this complex are on alluvial fans and flood plains. Bunderson loam, 1 to 3 percent slopes, eroded, occupies about 20 percent of the complex. It occurs as irregularly shaped slickspots that are interspersed with areas of Billings silty clay loam, 1 to 3 percent slopes.

The profile of the Billings soil is like the one described for the Billings series, except that some rill erosion and gully erosion have occurred. The profile of the Bunder-

son soil is the one described as typical for the Bunderson series. Included in mapping were areas of Ravola loam.

The surface layer of the Bunderson soil is platy and is nearly impervious to water. As a result, permeability and infiltration are very slow, especially in the surface layer. At depths of 10 to 20 inches, permeability is moderate. The surface of the Bunderson soil is nearly bare, except for scattered greasewood and pickleweed plants. About 11 inches of water is retained by this soil, but only about 4.5 inches is readily available to plants because of the high salt content in the upper 18 inches of the profile. Tiny crystals of salt are in the surface layer.

Runoff is rapid, and the soils of this complex are highly susceptible to erosion, especially during summer thunderstorms of high intensity. Gullying is variable, but in most areas the gullies are 10 to 20 feet deep and 500 to 1,300 feet apart. In addition, gullies 4 to 8 feet deep are eroding in a branching pattern, and head cutting is common.

The soils are better suited to production of range forage than to other uses. Reseeding of grasses and clearing of brush are not practical, because of the inadequate amount of rain. Proper use of the range and the control of gully erosion are the main management requirements. Plants growing on the Bunderson soil have no forage value. (The Billings soil is in capability unit VIIe-D, nonirrigated; Desert Loam Bottom range site. The Bunderson soil is in capability unit VIIIs-7, nonirrigated; not rated for other uses)

## Bunderson Series

The Bunderson series consists of well-drained, calcareous, medium-textured soils that are strongly affected by alkali. These soils are on alluvial fans, flood plains, and alluvial plains. They have formed in alluvium that washed from alkaline marine shale and sandstone. The vegetation is a sparse stand of pickleweed and greasewood. Most areas are bare and have a platy, nearly impermeable crust on the surface. Elevations range from 5,000 to 6,500 feet. The annual rainfall ranges from 6 to 11 inches, and the frost-free season ranges from 110 to 130 days. The mean annual soil temperature is between 47° and 54° F.

In a typical profile, the surface layer is light-gray to light brownish-gray, slightly hard loam about 4 inches thick. The underlying material is light brownish-gray silt loam and loam.

The Bunderson soils are used only for wildlife habitat.

Representative profile of Bunderson loam, 1 to 3 percent slopes, eroded, in a range area 1,400 feet east and 900 feet north of the SW. corner of section 25, T. 21 S., R. 6 E., in Emery County, Utah:

A11—0 to 1 inch, light-gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) when moist; moderate, medium, platy structure; hard, friable, nonsticky and slightly plastic; no roots; few medium and fine vesicular pores; strongly calcareous; moderately saline; very strongly alkaline (pH 9.3); abrupt, smooth boundary.

A12—1 to 4 inches, light brownish-gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) when moist; moderate, thin, platy structure; slightly hard, friable, nonsticky and slightly plastic; few fine roots; few very fine pores; strongly calcareous; strongly saline; very strongly alkaline (pH 10.0); abrupt, smooth boundary.

C1—4 to 11 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, subangular blocky structure; hard, friable, slightly sticky and plastic; few fine roots; few very fine pores; strongly calcareous; strongly saline; strongly alkaline (pH 8.7); clear, wavy boundary.

C2—11 to 18 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; massive; slightly hard, very friable, nonsticky and slightly plastic; few very fine roots; few, fine, discontinuous pores; strongly calcareous; strongly saline; moderately alkaline (pH 8.4); gradual, irregular boundary.

C3—18 to 31 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; massive; soft, very friable, nonsticky and slightly plastic; few very fine roots; few very fine pores; strongly calcareous; strongly saline; moderately alkaline (pH 8.0); clear, wavy boundary.

C4—31 to 38 inches, gray (2.5Y 6/1) silt loam, dark gray (2.5Y 4/1) when moist; massive; soft, friable, slightly sticky and plastic; few very fine roots; few very fine pores; strongly calcareous; strongly saline; moderately alkaline (pH 7.9); clear, wavy boundary.

C5—38 to 72 inches, light brownish-gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) when moist; massive; slightly hard, very friable, nonsticky and slightly plastic; few very fine roots; few fine pores; strongly calcareous; moderately saline; moderately alkaline (pH 7.9).

The content of exchangeable sodium ranges from 30 to 96 percent; it is greatest in the upper part of the profile and decreases with depth. Salinity ranges from moderate to strong. Lime content ranges from 5 to 25 percent. The soils are generally dry when not frozen. The A1 horizons have a hue of 2.5Y to 5Y; value is 6 or 7 when the soils are dry and 4 or 5 when they are moist; and chroma ranges from 2 to 4. The part of the profile between 10 and 40 inches is loam or silt loam, which contains 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand. Color of the upper 40 inches is about the same as that of the A1 horizons.

Bunderson soils occur with the Billings and Ravola soils. In this survey area, they were mapped only with these soils.

## Cache Series

The Cache series consists of deep, fine-textured, poorly drained, very strongly saline, nearly level or gently sloping soils on flood plains and alluvial fans. These soils have formed in alluvium that washed mainly from shale. The present vegetation is a sparse growth of greasewood, saltgrass, and pickleweed. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, the mean annual soil temperature is 47° to 54° F., and the frost-free season is 110 to 160 days.

In a typical profile, the suface layer is light brownish-gray, platy or granular silty clay loam about 3 inches thick. The underlying material is light brownish-gray silty clay that is mottled and gleyed in the lower part. A very strong salt horizon is less than 20 inches below the surface.

The Cache soils have a water table that is 20 to 40 inches below the surface most of the year. These soils are used mainly for wildlife habitat.

Representative profile of Cache silty clay is a range area 2,300 feet north and 1,800 feet east of the SW. corner of section 21, T. 20, S., R. 16 E., in Grand County, Utah:

A11sa—0 to ½ inch, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, platy breaking to moderate,

fine, granular structure; hard, firm, sticky and plastic; no roots; few very fine, vesicular pores; moderately calcareous; very strongly saline, many small salt crystals; strongly alkaline (pH 8.8); abrupt, smooth boundary.

A12sa—½ inch to 2½ inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, fine, granular structure; slightly hard, firm, sticky and plastic; no roots; few, very fine, vesicular pores; moderately calcareous; very strongly saline; many small salt crystals; strongly alkaline (pH 8.8); abrupt, smooth boundary.

C1sa—2½ to 7 inches, light brownish-gray (2.5Y 6/2) light silty clay, dark grayish brown (2.5Y 4/2) when moist; weak, medium, subangular blocky structure; very hard, firm, sticky and very plastic; few fine roots; few very fine discontinuous pores; strongly calcareous; very strongly saline; contains effloresced salt when dry; strongly alkaline (pH 8.6); clear, smooth boundary.

C2sa—7 to 17 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; intermixed with dark grayish-brown (10YR 4/2) material that is in seams and pockets and makes up 10 to 15 percent of horizon; weak, medium, subangular blocky structure; hard, very firm, sticky and very plastic; few very fine roots; few, very fine, discontinuous pores; strongly calcareous; very strongly saline; contains effloresced salt when dry; strongly alkaline (pH 8.8); diffuse, smooth boundary.

C3sa—17 to 33 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; moderate, fine, angular blocky structure; very hard; very firm, sticky and very plastic; few very fine roots; few, very fine, discontinuous pores; strongly calcareous; very strongly saline; contains effloresced salt when dry; strongly alkaline (pH 8.8); clear, smooth boundary.

C4sa—33 to 47 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; few, medium, distinct, brown (10YR 5/3) mottles; massive; very hard, very firm, sticky and very plastic; no visible roots or pores; strongly calcareous; very strongly saline; contains effloresced salt when dry; strongly alkaline (pH 8.6); clear, smooth boundary.

C5sa—47 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay, grayish brown (2.5Y 5/2) when moist; intermixed with brown (10YR 5/3) material that makes up about 30 percent of horizon; few, medium, distinct, light olive-brown (2.5Y 5/4) mottles; massive; very hard, very firm, sticky and very plastic; no visible roots or pores; strongly calcareous; very strongly saline; strongly alkaline (pH 8.6).

The content of soluble salts ranges from 2 to 5 percent to a depth of 30 inches or less, and it decreases, in some places, at depths of more than 30 inches. The content of exchangeable sodium ranges from 20 to 90 percent. The reaction ranges from mildly alkaline to strongly alkaline. Depth to the water table fluctuates, but typically it is between 20 to 40 inches. In the A1 horizons, the hue ranges from 7.5YR to 5Y; value ranges from 5 to 7 when the soils are dry and is 4 or 5 when they are moist; and chroma ranges from 2 to 4. The platy surface layer is ¼ to ½ inch thick, and it breaks easily to granules that contain numerous crystals of salt. The layer under the salt crust typically is granular and fluffy, and generally it contains crystals of salt and gypsum. The part of the profile between 10 and 40 inches is silty clay or clay. In this part hue ranges from 7.5YR to 5Y; value ranges from 5 to 7 when the soils are dry and from 4 to 6 when they are moist; and chroma ranges from 2 to 4.

**Cache silty clay** (0 to 3 percent slopes) (Ca).—The profile of this soil is the one described as typical of the series.

Included in the mapping, especially along the Green River, were some minor areas of soils that have intermixed brown colors. Also included were minor areas of heavy loams and of soils similar to the Cache soils, except that they are only moderately or strongly saline.

This Cache soil is poorly drained. The water table is 20 to 40 inches below the surface. It fluctuates with the seasons but is typically highest early in summer. Permeability is slow. Roots are concentrated in the surface layer but penetrate to a depth of 5 feet. In many places no roots have penetrated below a depth of 3 feet. Runoff is slow, and it is ponded in some places. Susceptibility to erosion is slight.

This soil is used mainly for wildlife habitat. (Capability unit VIIIw-8, nonirrigated; not rated for other uses)

## Castle Valley Series

The Castle Valley series consists of shallow, calcareous, well-drained, sloping to steep soils on upland benches and mesas. These soils have formed in material that weathered from sandstone and interbedded shale. Areas of these soils are generally surrounded by scarp faces of very steep Shaly colluvial land or Rock land. The vegetation is juniper, pinon, black sage, big sage, and Indian ricegrass. Elevations range from 5,000 to 7,200 feet. The annual rainfall is 8 to 12 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is brown loamy very fine sand. The subsoil is brown gravelly very fine sandy loam that has lime in the lower part. Sandstone bedrock is at a depth of about 10 inches.

These soils are used only for spring and fall range.

Representative profile of a Castle Valley very fine sandy loam, 2,400 feet north and 2,500 feet east of the SW. corner of section 15, T. 14 S., R. 9 E., in Carbon County, Utah:

A1—0 to 2 inches, brown (10YR 5/3) loamy very fine sand, dark yellowish brown (10YR 4/4) when moist; weak, thick, platy structure; soft, very friable, nonsticky and nonplastic; few fine and few medium roots; few fine pores; slightly calcareous; mildly alkaline (pH 7.6); clear, smooth boundary.

B2t—2 to 5 inches, brown (10YR 5/3) gravelly very fine sandy loam, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; soft, very friable, nonsticky and nonplastic; few medium and few fine roots; few fine pores; few thin, patchy clay films; noncalcareous; mildly alkaline (pH 7.5); clear, smooth boundary.

B2ca—5 to 10 inches, brown (10YR 5/3) gravelly very fine sandy loam, dark yellowish brown (10YR 4/4) when moist; massive; slightly hard, very friable, nonsticky and nonplastic; few medium and few fine roots and pores; many sandstone fragments; moderately calcareous; mildly alkaline (pH 7.6); abrupt, wavy boundary.

R—10 inches +, sandstone bedrock.

Depth to bedrock ranges from 10 to 20 inches. The soils are generally dry when not frozen. The B2t horizon has a hue of 10YR to 2.5YR; value is 5 to 7 when the soils are moist and 4 to 6 when they are dry; and chroma ranges from 3 to 6. Texture of the B2t horizon ranges from gravelly loamy very fine sand to gravelly loam, but typically it is gravelly very fine sandy loam. Flat, angular fragments of sandstone make up from 15 to 50 percent of the volume. The percentage of these fragments is highest near bedrock.

**Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded** (CeE2).—From 60 to 75 percent of this mapping unit is Castle Valley soil, and the rest is rock outcrop. The Castle Valley soil has the profile described as typical of the series. The texture of the surface layer is variable, however, because of deposition and removal of material by wind. In places as much as half of the original surface layer is gone.

Included in mapping were areas of soils less than 10 inches thick over sandstone and other areas in which the soils are more than 20 inches thick.

Drainage is good, and permeability is moderately rapid. Roots penetrate to the sandstone and then spread horizontally. From 2 to 3 inches of available water is retained by this soil; the amount depends on the depth to sandstone. Runoff is slow to medium, but the amount of runoff is high because of the areas of bare rock. The susceptibility to further erosion from wind and water is slight to high. Many areas contain deep ravines.

This mapping unit is used for spring and fall range. Posts are cut from juniper in favorable sites. (Capability unit VIIs–S3, nonirrigated; Semi-Desert Stony Hills (Pinon-Juniper) range site)

## Cedar Mountain Series

The Cedar Mountain series consists of shallow, well-drained, fine-textured, undulating to steep soils that formed in residuum weathered from shale. These soils occupy hills, mainly along the eastern edge of the survey area. The vegetation is mainly galletagrass, shadscale, Nuttal saltbush, juniper, and pricklypear cactus. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is weak-red shaly clay loam about 3 inches thick, and the subsoil is reddish-brown shaly silty clay and weak-red shaly silt loam. Slightly weathered, reddish-gray shale bedrock is at a depth of about 14 inches.

Cedar Mountain soils are used for spring and winter grazing of livestock.

Representative profile of a Cedar Mountain shaly clay loam, 2,600 feet south and 2,980 feet east of the NW. corner of section 17, T. 17 S., R. 11 E., in Emery County, Utah:

A1—0 to 3 inches, weak-red (2.5YR 5/2) shaly clay loam, reddish brown (2.5YR 4/4) when moist; coarse fragments occur mainly as a mantle on the surface; weak, medium, platy structure breaking to moderate, fine, granular structure; slightly hard, very firm, sticky and very plastic; few medium and few fine roots; vesicular pores; moderately calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

B2ca—3 to 7 inches, reddish-brown (2.5YR 5/3) shaly silty clay, reddish brown (2.5YR 4/4) when moist; weak, coarse, prismatic structure; very hard, very firm, sticky and very plastic; few medium and few fine roots; few medium and few fine pores; strongly calcareous; moderately alkaline (pH 8.2); clear, wavy boundary.

B3ca—7 to 14 inches, weak-red (2.5YR 4/2) shaly heavy silt loam, both dry and moist; massive; few very fine roots; strongly calcareous; moderately alkaline (pH 8.2).

R—14 inches +, reddish-gray (10R 5/1), slightly weathered shale, dark reddish gray (10R 4/1) when moist; moderately calcareous.

In the A1 horizon, the hue ranges from 2.5YR to 5YR; value ranges from 5 to 7 when the soils are dry and from 4 to 6 when they are moist; and chroma ranges from 2 to 4. Shale fragments make up 25 to 50 percent of the matrix but are mainly on the surface. Cedar Mountain soils are generally dry when not frozen. Clay minerals are mixed but mainly are montmorillonitic. The texture throughout the profile is silty clay to heavy silt loam, but the average clay content is less than 35 percent. Hue in the B2ca horizon ranges from 2.5YR to 5YR; value is 4 to 6 when the soils are dry and 4 or 5 when they are moist; and chroma is 3 or 4. The content of exchangeable sodium ranges from 15 to 50 percent. Structure ranges from weak prismatic to strong prismatic.

**Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded** (CmF2).—The profile of this soil is the one described as typical of the series. It has fragments of shale ranging from 1 to 4 inches in diameter on the surface. Rills and shallow gullies are common. Gullies 2 to 5 feet deep are in the bottoms of most canyons.

Included with this soil in mapping were areas of shallow soils over sandstone and some nearly bare areas of Badland. Also included were areas of deep, gravelly, loamy soils in the bottoms of narrow canyons.

Drainage is good, and permeability is slow. Roots penetrate to the shale. About 3 inches of available water is held by this soil, the amount depending on the depth to shale. Runoff is generally rapid, and the susceptibility to further erosion is high.

This soil is used for spring and winter grazing. Controlling erosion and regulating the amount and season of range use are needed. (Capability unit VIIe–D3X, nonirrigated; Desert Red Shale range site)

## Chipeta Series

Soils of the Chipeta series are calcareous, well drained, moderately fine textured, and gently rolling to moderately steep. They occupy shale hills and have formed in residuum that weathered from alkaline, gypsum-bearing marine shale. The vegetation is mainly mat saltbush, Gardner saltbush, and shadscale. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, hard silty clay loam about 5 inches thick. The underlying material is light brownish-gray, slightly to moderately saline silty clay and silty clay loam. Slightly weathered marine shale bedrock is at a depth of about 17 inches.

Most areas of these soils are used for range. Small areas have been cleared and are used for irrigated alfalfa, grain, and pasture.

Representative profile of Chipeta silty clay loam, 1 to 3 percent slopes, in a cultivated area 1,000 feet south and 20 feet east of the NW. corner of section 11, T. 19 S., R. 8 E., in Emery County, Utah:

Ap—0 to 5 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, angular and subangular blocky structure; hard, firm, sticky and plastic; few fine and medium-sized roots; few fine, discontinuous pores; strongly calcareous; mildly alkaline (pH 7.7); clear, smooth boundary.

C1—5 to 13 inches, light brownish-gray (2.5Y 6/2) heavy silty clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, medium and fine, angular blocky structure; hard, very firm, sticky and plastic; few fine and medium-sized roots; few, large, continuous pores and few, fine, discontinuous pores; strongly calcareous; mildly alkaline (pH 7.6); clear, wavy boundary.

C2cs—13 to 17 inches, light brownish-gray (2.5Y 6/2) light silty clay, dark grayish brown (2.5Y 4/2) when moist; weak, moderately thick, platy structure breaking to weak, medium, angular blocky structure; hard, very firm, sticky and plastic; few fine and medium-sized roots; many fine gypsum crystals and mycelialike veins; 20 percent shale fragments; strongly calcareous; mildly alkaline (pH 7.4); gradual, irregular boundary.

R—17 inches +, slightly weathered marine shale.

Salinity ranges from moderate to strong. Depth to shale ranges from 10 to 20 inches. Unless irrigated, the soils are generally dry when not frozen. In the A horizon, the hue ranges from 2.5Y to 5Y; value ranges from 6 to 8 when the soils are dry and from 4 to 6 when they are moist; and chroma is 1 or 2. The part of the profile between 10 inches and shale is heavy silty clay loam to light silty clay that contains more than 35 percent clay. Hue in this part ranges from 2.5Y to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; and chroma is 1 or 2. The content of gypsum in the C2cs horizon ranges from 0.5 to 11 percent. Gypsum crystals are few to common.

Chipeta soils occur with Persayo soils and with areas of Badland.

**Chipeta-Badland association, 3 to 30 percent slopes, eroded** (CBF2).—This mapping unit is dominantly Chipeta silty clay loam, 3 to 20 percent slopes, eroded, but about 20 percent of it consists of areas of Badland and of minor areas of Persayo soils. Badland generally has slopes of less than 30 percent, but in places slopes of as much as 50 percent were included in mapping.

In most places the profile of the Chipeta soil in this mapping unit is about 10 inches thick. Otherwise, the profile is like the one described for the series. The Chipeta soil typically is saline. After a rain, numerous white, salty spots are on the surface. The vegetation is mainly mat saltbush and Castle Valley clover.

Runoff is rapid, and erosion is active. The soils are readily dispersed by raindrops, and the susceptibility to further erosion is very high. Sheet and rill erosion are common. Runoff from the soils of this mapping unit accelerates gully erosion on the lower slopes.

This mapping unit is suited only to range. (The Chipeta soil is in capability unit VIIe-D3, nonirrigated; Desert Shale range site. Badland is in capability unit VIIIs-7; nonirrigated; not rated for other uses)

**Chipeta-Persayo association, 1 to 3 percent slopes** (CPB).—This mapping unit consists of about 60 percent Chipeta silty clay loam, 1 to 3 percent slopes, and of about 40 percent Persayo loam, 1 to 3 percent slopes. These soils are intermingled and occur in no consistently identifiable pattern. Consequently, they were not separated in mapping. As a rule, the Chipeta soil is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were some areas of very shallow unnamed soils. Also included were other soils that are 20 to 40 inches thick over shale and small areas, generally less than 1 acre in extent, of strongly saline-alkali soils.

The profile of Chipeta silty clay loam, 1 to 3 percent slopes, is the one described as typical for the series. In most places this soil is 10 to 20 inches thick over shale. It has good drainage and is slowly permeable. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale and then spread horizontally. This Chipeta soil retains about 3 inches of available water. The soil is hard to work and to irrigate. Leveling is not practical, because this soil is too shallow.

The Persayo soil in this mapping unit has a profile like the one described for the Persayo series. Erosion has mainly caused the formation of rills and shallow gullies.

The dominant use of the soils in this mapping unit is spring and fall range. Alfalfa, grain, and pasture plants are grown in the irrigated areas, but the soils are poorly suited to those crops. Hay and pasture effectively reduce soil losses most of the time. (Both soils are in capability unit VIe-23, irrigated. The Chipeta soil is in capability unit VIIe-D3, nonirrigated; Desert Shale range site. The Persayo soil is in capability unit VIIe-D4, nonirrigated; Desert Loamy Shale range site)

**Chipeta-Persayo association, 3 to 20 percent slopes, eroded** (CPE2).—About 60 percent of this mapping unit is Chipeta silty clay loam, 3 to 20 percent slopes, eroded, and about 40 percent is Persayo loam, 3 to 20 percent slopes, eroded. These soils are intermingled and occur in no consistently identifiable pattern. The Chipeta soil generally is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were areas of soils having slopes of 1 to 3 percent and small areas of shale outcrop, or Badland. Also included in places were small spots that are strongly saline.

The soils in this mapping unit are highly susceptible to further erosion. Runoff is rapid, and it causes accelerated sheet and gully erosion. Many areas contain gullies that are 2 to 5 feet deep and 100 to 300 feet apart. A moderate amount of sheet erosion has taken place.

The soils in this mapping unit are suited to range and are used for that purpose. (The Chipeta soil is in capability unit VIIe-D3, nonirrigated; Desert Shale range site. The Persayo soil is in capability unit VIIe-D4, nonirrigated; Desert Loamy Shale range site)

## Ferron Series

The Ferron series consists of deep, poorly drained, medium-textured soils that are calcareous and nearly level or gently sloping. These soils are on alluvial fans and flood plains and in the bottoms of narrow alluvial valleys. They have formed in alluvium that washed from alkaline marine shale and sandstone. The vegetation is mainly wiregrass, sedge, redtop grass, and saltgrass. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, moderately calcareous, slightly hard silt loam about 3 inches thick. It contains considerable organic matter from grass roots. The underlying material is light brownish-gray loam or very fine sandy loam that in places contains thin layers of clay loam or sandy loam. Veins of gypsum are common.

The Ferron soils are mottled or gleyed at a depth of less than 20 inches. The water table is near the surface

most of the year. These soils are used for wet meadow pasture.

Representative profile of Ferron silt loam in a pasture, 350 feet north and 20 feet west of the SE. corner of section 11, T. 17 S., R. 8 E., in Emery County, Utah:

O1—1 inch to 0, undecomposed organic material, mainly grass roots; strongly calcareous; moderately alkaline (pH 8.3); abrupt, smooth boundary.

A1g—0 to 3 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; common, fine, prominent, yellowish-red (5YR 4/8) mottles and common, medium, faint, dark-gray (2.5Y 4/0) mottles; weak, thick, platy structure breaking to weak, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many fine and few medium roots; few medium and fine pores; moderately calcareous; moderately alkaline (pH 8.2); clear, smooth boundary.

C1g—3 to 15 inches, light brownish-gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) when moist; many, medium, distinct, light olive-brown (2.5Y 5/6) mottles; weak, moderately thick, platy structure breaking to weak, medium, granular structure; soft, friable, nonsticky and slightly plastic; plentiful medium and fine roots; common fine pores; numerous gypsum mycelia; moderately calcareous; mildly alkaline (pH 7.8); gradual, wavy boundary.

C2g—15 to 60 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, grayish brown (2.5Y 5/2) when moist; many, medium and faint, light olive-brown (2.5Y 5/6) mottles; massive; soft, friable, nonsticky and nonplastic; common medium and a few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7).

The content of lime ranges from 10 to 25 percent, salinity ranges from slight to strong, and reaction ranges from mildly to strongly alkaline. Ferron soils are mottled within 20 inches of the surface. The water table is at a depth of 6 to 36 inches below the surface, depending on the season. In the A1g horizon, the hue ranges from 2.5Y to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; and chroma is 1 or 2. The part of the profile between 10 and 40 inches is very fine sandy loam to light silt loam that contains less than 18 percent clay and less than 15 percent sand coarser than very fine sand. Hue in this part ranges from 2.5Y to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; and chroma is 2.

**Ferron silt loam** (0 to 3 percent slopes) (Fr).—The profile of this soil is the one described for the series. This soil generally occurs in small, low areas that receive seepage water from canals or from irrigated areas higher on the slopes. It is typically mottled to the surface, but in places mottles occur at a depth below 20 inches. The surface layer is rich in organic matter and is moderately saline in places.

Included in the mapping were small areas of very strongly saline-alkali soils and small areas of soils in which the water table is at a moderate depth.

Drainage is poor, and permeability is moderate. Because of the high water table, most roots penetrate only to a depth of 30 inches or less. Runoff is slow, and the susceptibility to erosion is slight. The large amount of organic matter in the surface layer contributes to fertility, but this soil is low in natural fertility. Pastures that are dry enough for the application of fertilizer respond well to nitrogen and phosphorus.

This soil is used only for grazing. Livestock can graze some areas only in winter when the soil is frozen. (Capability unit Vw-2W, nonirrigated; Wet Meadow range site)

## Ferron Series, Heavy Variant

This variant of the Ferron series consists of soils that are similar to the normal Ferron soils except that the texture is heavier. In the soils of the variant, the texture in that part of the profile between 10 and 40 inches is heavy silt loam or silty clay loam.

Representative profile of Ferron silty clay loam, heavy variant, in a pasture, 1,800 feet south and 1,800 feet east of the NW. corner of section 4, T. 18 S., R. 9 E., in Emery County, Utah:

A11—0 to 2 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark gray (2.5Y 4/1) when moist; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, platy structure; hard, firm, sticky and plastic; abundant fine and few large roots; strongly calcareous, and lime is disseminated; moderately alkaline (pH 8.4); clear, smooth boundary.

A12—2 to 9 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) when moist; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, thick, platy structure; hard, firm, sticky and plastic; plentiful medium roots; few fine pores; strongly calcareous and lime is disseminated; moderately alkaline (pH 8.2); gradual, wavy boundary.

C1—9 to 19 inches, light brownish-gray (2.5Y 6/2) heavy silt loam, grayish brown (2.5Y 5/2) when moist; few, fine, distinct, yellowish-brown (10YR 5/4) mottles; weak, thick, platy structure; slightly hard, firm, slightly sticky and plastic; plentiful fine roots; many medium pores; strongly calcareous, and lime is disseminated; moderately alkaline (pH 8.2); gradual, irregular boundary.

C2g—19 to 50 inches, light brownish-gray (2.5Y 6/2) heavy silt loam, light olive brown (2.5Y 5/3) when moist; common, medium, distinct, yellowish-brown (10YR 5/6) and common, medium, faint, gray (2.5Y N 5/0) mottles; massive; slightly hard, friable, nonsticky and slightly plastic; few fine roots; common fine pores; strongly calcareous, and lime is disseminated; moderately alkaline (pH 8.2); gradual, irregular boundary.

C3g—50 to 65 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) when moist; common, medium, prominent, yellowish-red (5YR 5/8) mottles and common, medium, faint, gray (2.5Y N 5/0) mottles; massive; hard, firm, slightly sticky and plastic; strongly calcareous, and lime is disseminated; moderately alkaline (pH 8.4).

**Ferron silty clay loam, heavy variant** (0 to 3 percent slopes) (Fe).—This soil occurs in small, low areas that receive seep water from higher lying canals and irrigated areas. Its profile is the one described for the heavy variant of the Ferron series.

Grazing is the only use of this soil. Some areas can be grazed only in winter when the soil is frozen. (Capability unit Vw-2W, nonirrigated; Wet Meadow range site)

## Green River Series

The Green River series consists of deep, stratified, moderately well drained, medium-textured soils on low stream terraces and flood plains. These soils have formed in alluvium derived from mixed sedimentary rocks. They are flooded at least once every 5 to 10 years. The vegetation is mainly squawbush, greasewood, saltgrass, and cottonwood trees. Most areas have been cleared and are used for crops. Elevations range from 4,000 to 4,300 feet. The annual rainfall is 5 to 6 inches, and the mean an-

nual soil temperature is between 47° and 54° F. The frost-free season is 140 to 160 days in 3 out of 4 years.

In a typical profile, the surface layer is brown loam about 11 inches thick. The underlying material is pale-brown very fine sandy loam and silt loam to a depth of about 25 inches. Below this is pale-brown loamy fine sand, loam, and fine sand.

The Green River soils typically are more than 5 feet deep over gravel. They occupy large areas on the nearly level flood plains of the Green River. Depth to the water table ranges from 20 to 40 inches, but generally it is more than 30 inches. Crops grown under irrigation are alfalfa, corn, small grains, melons, and sugar beets, and some areas are used for irrigated pasture.

Representative profile of Green River loam in a cultivated field, 2,600 feet west and 1,600 feet south of the NE. corner of section 10, T. 21 S., R. 16 E., in Emery County, Utah:

Ap—0 to 11 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; weak, medium, platy structure; slightly hard, friable, slightly sticky and slightly plastic; plentiful fine and few medium roots; few fine pores; moderately calcareous; moderately alkaline (pH 7.9); clear, smooth boundary.

IIC1—11 to 15 inches, pale-brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) when moist; few, fine, distinct, yellowish-brown (10YR 5/8) mottles; massive to very weak, medium, subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; few fine roots and few fine pores; moderately calcareous; moderately alkaline (pH 8.0); gradual, wavy boundary.

IIC2—15 to 19 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; few, fine, distinct, dark yellowish-brown (10YR 4/6) mottles; massive; soft, very friable, slightly sticky and slightly plastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 7.9); clear, wavy boundary.

IIIC3—19 to 25 inches, pale-brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) when moist; few, fine, distinct, dark yellowish-brown (10YR 4/6) mottles; massive; soft, very friable, nonsticky and nonplastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 8.0); abrupt, wavy boundary.

IVC4—25 to 38 inches, pale-brown (10YR 6/3) loamy fine sand, dark brown (10YR 4/3) when moist; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; massive; soft, very friable, nonsticky and nonplastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 8.2); clear, smooth boundary.

VC5—38 to 45 inches, pale-brown (10YR 6/3) light loam, dark brown (10YR 4/3) when moist; common, fine, distinct, dark yellowish-brown (10YR 4/6) mottles; massive; soft, friable, nonsticky and nonplastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 7.9); clear, smooth boundary.

VIC6—45 to 60 inches, pale-brown (10YR 6/3) fine sand, dark brown (10YR 4/3) when moist; single grain; loose both when dry and when moist, nonsticky and nonplastic; very few fine roots; moderately calcareous; moderately alkaline (pH 8.1).

The content of calcium carbonate ranges from 5 to 35 percent. Mottles are at a depth between 10 and 30 inches. In the A horizon, the hue is 10YR; value is 5 or 6 when soils are dry and 4 or 5 when they are moist; and chroma is 3. The part of the profile between 10 and 40 inches is loamy fine sand to silt loam. This material contains less than 18 percent clay and more than 15 percent sand that is coarser than very fine sand. The hue in this part is 10YR or 7.5YR; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; and chroma is 3 or 4.

**Green River loam** (0 to 1 percent slopes) (Gr).—This soil has the profile described as typical of the series. The surface layer is loam, and the underlying material is sandy loam or very fine sandy loam. Stratification is common below a depth of 40 inches, and the texture ranges from fine sand to loam.

Included in mapping were some areas in which the surface layer is sandy loam, and other areas in which the underlying material is silt loam. Other inclusions consist of small areas of soils that are moderately or strongly saline; of small areas of sandy soils; and of about 20 acres of soils that have a surface layer of silty clay loam 8 to 12 inches thick.

Drainage is only moderately good. Water moves laterally in the soil, and this allows the root zone to receive enough air to reduce the effects of restricted drainage. Permeability is moderate, and roots can penetrate deeply. This soil retains about 7 to 8 inches of water, but only 3.5 to 4 inches of water is readily available to plants. Runoff is slow. This soil is not susceptible to erosion, and it is easy to work and to irrigate. Most areas have been leveled.

Crops grown under irrigation are alfalfa, melons, small grains, corn, and sugar beets. Some areas are used for irrigated pasture. (Capability unit IIw–1, irrigated; not rated for other uses)

**Gullied land** (Gu) is widely distributed and makes up about 2.3 percent of the survey area. Some of the large areas are Washboard Wash near Elmo, Major Wash south of Huntington, Quitchupah Creek south of Emery, Miller Creek south of Price, and Soldier Creek east of Wellington (fig. 11). The vegetation is mainly greasewood.

Gullies are started by runoff from occasional summer storms of high intensity, by water escaping from broken irrigation canals, or by waste water from irrigation. This water, supplemented by water that seeps from adjoining fields through animal burrows and soil cracks, saturates the soil in the bottom of the gully. Erosion of the saturated soil undermines the side banks of the gully and causes them to topple. Repeated undercutting and caving gradually widen the gully. Small streams of water flow-

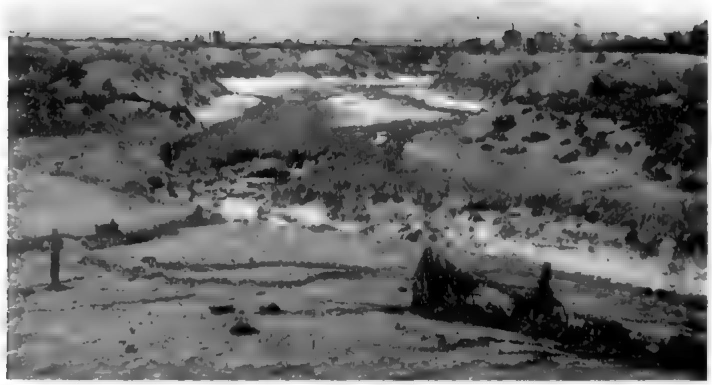

*Figure 11.*—An area of Gullied land, called Major Wash, south of Huntington. The white spots are accumulations of salt.

ing into the main gully form additional little side gullies that deepen and widen through head cutting to form a network of gullies that drain into the main large gully. Areas of Gullied land are as much as a quarter of a mile wide. Within each area shown on the soil map, the main central gully is 10 to 25 feet deep and 50 to 150 feet wide. Gullies generally are less than 100 feet apart.

Gullied land has little or no value for farming. It is used by wildlife and, in places, for limited grazing. It also provides drainage outlets for adjacent soils. Waste water from irrigated areas should be disposed of through metal pipe outlets, however, or the cropland adjoining the gullies will be lost. (Capability unit VIIIe–2, nonirrigated; not rated for other uses)

## Harding Series

Soils of the Harding series are deep, calcareous, and well drained or moderately well drained, and they are fine textured or moderately fine textured. They occupy benches and mesas and have formed in alluvium that washed from sedimentary rocks. Moderately large areas occur on mesas north of Emery and east of Castle Dale. The vegetation is shadscale, galletagrass, pygmy sagebrush, and alkali sacaton. Elevations range from 6,000 to 6,700 feet. The annual rainfall is 8 to 12 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season ranges from 110 to 130 days.

In a typical profile, the surface layer is light brownish-gray very fine sandy loam about 2 inches thick. The subsoil is pale-brown sandy clay loam and heavy clay loam that is strongly affected by alkali. It is about 10 inches thick and has prismatic structure. The substratum is very pale brown, white, and light-gray clay, clay loam, and loam that is massive, hard, and strongly calcareous.

Harding soils are used only for spring and fall range.

Representative profile of Harding very fine sandy loam, 2,800 feet west and 2,600 feet south of the NE. corner of section 26, T. 21 S., R. 6 E., in Emery County, Utah:

A2—0 to 2 inches, light brownish-gray (10YR 6/2) very fine sandy loam, brown (10YR 5/3) when moist; weak, thick, platy structure breaking to weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; few large and few fine roots; few medium pores; strongly calcareous; moderately alkaline (pH 8.1); clear, smooth boundary.

B21t—2 to 4 inches, pale-brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) when moist; weak, coarse, prismatic structure breaking to moderate, very fine, angular blocky structure; hard, firm, sticky and plastic; few medium roots; few fine pores; few thin clay films on peds; strongly calcareous; moderately alkaline (pH 8.3); clear, smooth boundary.

B22tca—4 to 10 inches, pale-brown (10YR 6/3) heavy clay loam, brown (10YR 5/3) when moist; weak, coarse, prismatic structure breaking to moderate, medium, angular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; few fine pores; few thin clay films on peds; strongly calcareous; moderately alkaline (pH 8.3); gradual, wavy boundary.

C1ca—10 to 20 inches, very pale brown (10YR 8/3) clay, very pale brown (10YR 7/3) when moist; massive; hard, firm, slightly sticky and plastic; few fine roots; few fine pores; very strongly calcareous; strongly saline; strongly alkaline (pH 8.5); gradual, wavy boundary.

C2ca—20 to 29 inches, white (10YR 8/2) clay loam, light gray (10YR 7/2) when moist; massive; slightly hard to hard, firm, slightly sticky and plastic; few fine roots; few fine and medium pores; very strongly calcareous; strongly saline; strongly alkaline (pH 8.7); diffuse, irregular boundary.

C3cs—29 to 52 inches, light-gray (10YR 7/2) heavy loam, light brownish gray (10YR 6/2) when moist; massive; slightly hard to hard, firm, slightly sticky and plastic; no roots; few fine pores; very strongly calcareous; strongly saline; moderately alkaline (pH 8.4); common, fine gypsum nodules.

The solum ranges from 8 to 16 inches in thickness. Unless irrigated, the soils generally are dry when not frozen. In the A2 horizon, the hue is 10YR or 7.5YR; value ranges from 6 to 8 when the soils are dry and is 5 or 6 when they are moist; and chroma is 2 or 3. Structure of the A2 horizon is platy, and it ranges from weak to moderate and from thin to thick. The A2 horizon is absent in some places. In the B2t horizons, the hue ranges from 10YR to 7.5YR; value is 6 or 7 when the soils are dry and is 4 or 5 when they are moist; and chroma is 3 or 4. Texture in these horizons ranges from sandy clay loam to silty clay or clay, and the average clay content is more than 35 percent. Reaction ranges from moderately alkaline to very strongly alkaline.

The number of clay films ranges from few to many, and typically the clay films are thin. Staining by organic matter generally is evident on the surface of the peds. Structure of the B2t horizons is weak to strong prismatic or columnar, and it breaks to moderate or strong, angular blocky. The calcium carbonate equivalent ranges from 15 to 40 percent. In the Cca horizons, the texture ranges from heavy loam to clay. Salinity is strong or very strong, and generally it increases with depth. Alkalinity ranges from moderately alkaline to very strongly alkaline. The content of gypsum ranges from 1 to 10 percent. In some places below a depth of 20 inches, the profile contains a small amount of gravel.

**Harding very fine sandy loam** (1 to 3 percent slopes) (Ha).—The profile of this soil is the one described as typical of the series. Included in mapping was a small area about 4 miles east of Castle Dale in which the soil is only about 20 inches thick over shale. In this included area, the surface layer and subsoil are similar to those in the typical Harding profile, but the gypsum layer is on top of the shale. Also included were soils not strongly affected by alkali.

Drainage is moderately good or good and permeability is slow. Roots generally penetrate no deeper than 30 inches. Where this soil is underlain by shale, roots penetrate only to the shale. Runoff is medium. This soil is moderately susceptible to erosion. It retains about 11 inches of water, but only about 5.5 inches of water is readily available to plants. Less than this amount is supplied by the limited precipitation.

This soil is suited to spring and fall grazing and is used for that purpose. (Capability unit VIIs–S4, nonirrigated; Semi-Desert Limy Loam range site)

## Hunting Series

Soils of the Hunting series are deep, gently sloping, and slightly to strongly saline. They are also medium textured and are somewhat poorly drained. These soils are on alluvial fans and flood plains and in narrow alluvial valleys, where they have formed in alluvium that washed from marine shale and sandstone. The vegetation is mainly saltgrass or redtop grass, but greasewood grows in places. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The growing season ranges from 110 to 160 days.

In a typical profile, the surface layer is light brownish-

gray, strongly calcareous loam about 9 inches thick. The underlying material is light brownish-gray and grayish-brown loam that contains a large amount of lime. Distinct mottles are at some depth between 20 and 40 inches.

The Hunting soils have a water table that is 20 to 40 inches below the surface. Most areas of Hunting soils are cultivated. Crops grown under irrigation are alfalfa, small grains, and sugar beets. Some areas are used for irrigated pasture.

Representative profile of Hunting loam in a cultivated field, 950 feet west and 300 feet south of the NE. corner of section 19, T. 19 S., R. 8 E., in Emery County, Utah:

Ap—0 to 9 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few large and few fine roots; few medium and fine pores; strongly calcareous; moderately alkaline (pH 8.0); gradual, smooth boundary.

C1—9 to 27 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine roots; few medium and fine pores; strongly calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

C2—27 to 30 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; massive; hard, firm, slightly sticky and slightly plastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 7.9); gradual, smooth boundary.

C3g—30 to 60 inches, grayish-brown (2.5Y 5/2) loam, dark grayish-brown when moist; few, medium, distinct, dark yellowish-brown (10YR 4/5) mottles; massive; slightly hard, friable, nonsticky and nonplastic; very few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 8.2).

Salinity and alkalinity range from slight to strong, and the content of lime ranges from 10 to 25 percent. The A horizon has a texture of loam or silty clay loam. In this horizon the hue is 2.5Y or 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; and chroma is 2. The part of the profile between 10 and 40 inches is loam or silt loam that contains more than 18 percent clay and less than 15 percent sand coarser than very fine sand. This part also has veins of gypsum in some places. The C horizon below a depth of 40 inches is stratified in some places with sandy loam or clay loam. The color of the upper 30 inches is about the same.

**Hunting loam** (1 to 3 percent slopes) (Hn).—The profile of this soil is the one described as typical of the series. This soil generally occurs in areas of moderate size. The subsoil is mostly loam, but the texture below a depth of 40 inches ranges from clay loam to sandy loam. Typically, mottles are at a depth between 20 and 40 inches, but they are at a greater depth in places. Veins of gypsum are common, and the substratum contains 1 to 3 percent gypsum in most places.

Included in mapping were areas of soils that have a surface layer of silt loam, and other areas where the surface layer and subsoil are brown or dark brown. Also included were areas of Billings silty clay loam, areas of Rafael silty clay loam, and small spots of strongly saline-alkali soils.

Drainage is somewhat poor, and permeability is moderate. Roots penetrate deeply. Runoff is medium, and the hazard of erosion is moderate. This soil is easy to cultivate. About 12 inches of water is held by this soil, but only about 5 inches of water is readily available to plants.

Seepage from irrigation canals and overirrigation of fields in higher areas contribute seepage water to these soils. Preventing seepage by lining irrigation canals and ditches and correct water application is less expensive and as effective as draining these soils. Excess water should be removed before these soils are used for crops.

Alfalfa, small grains, and sugar beets are grown under irrigation, but irrigated pasture is probably the dominant use because of the high water table. Alfalfa generally produces two full crops and a part of a third crop each year. (Capability unit IIIw-2, irrigated; not rated for other uses)

**Hunting loam, moderately saline** (1 to 3 percent slopes) (Hs).—The profile of this soil is similar to the one described as typical for the series, except that it is moderately saline.

Included in mapping were nearly level areas near Green River and areas in which the surface layer is silty clay loam 8 to 14 inches thick. Also included were spots, generally less than 1 acre in extent, of strongly saline soils.

Soil limitations caused by the water table and accumulations of salts are more severe in areas that receive seepage from irrigation ditches and canals. In some places overirrigation contributes to wetness. Salinity has reduced the amount of water readily available to plants to about 3 inches. Preventing losses of water through overirrigation and through seepage from ditches and canals improves soil drainage and helps in reclaiming this soil.

The main use of this soil is for irrigated pasture. Crops should be selected for their tolerance to salt. Alfalfa and small grains are grown, but this soil is not well suited to these crops. (Capability unit IVs-28, irrigated; not rated for other uses)

**Hunting silty clay loam** (1 to 3 percent slopes) (Hu).—This soil is similar to the one for which a profile is described as typical for the series, except that the surface layer is silty clay loam 8 to 15 inches thick. In addition, the rate of infiltration is slower.

This soil is hard to till. The seedbed is more easily prepared if the soil is plowed in fall when it is barely moist, and if it is left rough over winter, than when it is plowed in spring.

Alfalfa, small grains, and sugar beets are grown under irrigation, and some areas are used for irrigated pasture. (Capability unit IIIw-2, irrigated; not rated for other uses)

## Kenilworth Series

Soils of the Kenilworth series are stony, well drained, gently sloping to steep, and moderately coarse textured. They occupy high benches on old dissected outwash plains below very steep mountains along the western edge of the survey area. These soils have formed in a thick deposit of strongly to very strongly calcareous stony alluvium derived mainly from calcareous sandstone, quartzite, and limestone. The vegetation is mainly juniper and pinon. Elevations range from 6,000 to 7,200 feet. The annual rainfall is 8 to 12 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is pale-brown, very strongly calcareous very stony sandy loam about 7

inches thick. The underlying material is pale brown and very pale brown stony sandy loam that is very strongly calcareous and contains 25 to 50 percent cobblestones and stones.

The Kenilworth soils are used for range. Some areas have been cleared for reseeding, but inadequate rainfall and stones on the surface prevent the success of such work in many places.

Representative profile of a Kenilworth very stony sandy loam, 1,400 feet north and 300 feet west of the SE. corner of section 6, T. 17 S., R. 8 E., in Emery County, Utah:

A1—0 to 7 inches, pale-brown (10YR 6/3) very stony sandy loam, dark brown (10YR 4/3) when moist; moderate, fine, granular structure; soft, very friable slightly sticky and slightly plastic; few large, plentiful, medium and fine roots; no pores; strongly calcareous; mildly alkaline (pH 7.7); clear, smooth boundary.

C1ca—7 to 13 inches, very pale-brown (10YR 7/3) stony sandy loam, pale brown (10YR 6/3) when moist; weak, medium to coarse, angular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few medium and fine roots; few medium and fine pores; very strongly calcareous; moderately alkaline (pH 8.0); gradual, wavy boundary.

C2—13 to 21 inches, pale-brown (10YR 6/3) stony sandy loam, brown (10YR 5/3) when moist; weak, medium to coarse, angular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; few medium and fine roots; common fine and a few medium pores; strongly calcareous; moderately alkaline (pH 8.2); gradual, wavy boundary.

C3—21 to 34 inches, pale-brown (10YR 6/3) stony sandy loam, brown (10YR 5/3) when moist; massive; hard, very friable, slightly sticky and slightly plastic; few medium and fine roots; few fine pores; strongly calcareous; strongly alkaline (pH 8.5).

Stones and cobblestones occupy from 0.1 to 3.0 percent of the surface, and they range from 3 inches to 4 feet in diameter. Limy horizons are within 3 to 9 inches of the surface. The Kenilworth soils generally are dry when not frozen. In the A1 horizon, the hue is 10YR; value is 5 or 6 when the soils are dry and is 4 or 5 when they are moist; and chroma is 2 or 3. The part of the profile between 10 and 40 inches is stony sandy loam to stony light loam that is less than 18 percent clay and is more than 15 percent sand coarser than very fine sand. The hue in this part is 10YR; value is 6 or 7 when the soils are dry and 5 or 6 when they are moist; and chroma is 3 or 4. The content of lime ranges from 30 to 45 percent. The content of stones and cobblestones ranges from 25 to 50 percent.

**Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded** (KeE2).—The profile of this soil is the one described as typical of the series. This soil occurs in large areas. Sheet erosion is active. Lime-coated gravel and cobblestones are on the surface in many places, and coatings of lime are on stones 2 to 6 inches above the surface. These lime-coated stones indicate that erosion has removed soil from around them. Gullies 2 to 3 feet deep are common in places.

Included in mapping were areas in which the subsoil is clay loam. Also included on Wood Hill north of Price was one small area of soils in which the solum contains a hardpan of indurated lime.

This Kenilworth soil is well drained and is moderately permeable. Runoff is medium, and the susceptibility to erosion is slight to moderate. The root zone is shallow or moderately deep. Depth of root penetration is restricted by limy layers and stones. This soil retains about 4.5 inches of water, but only about 3.5 inches of water is readily available to plants.

This soil is used mainly as spring and fall range. Deer use it also for winter range. In places juniper is cut for fence posts. (Capability unit VIIs-SX, nonirrigated; Semi-Desert Stony Loam (Pinon-Juniper) range site)

## Killpack Series

The Killpack series consists of well-drained, moderately fine textured, slightly to moderately saline soils. The soils have formed in residuum that weathered from clayey marine shale bedrock, and they contain weak to moderate salt of gypsum horizons. They are nearly level or gently sloping and occur in areas of small to moderate size on shale hills, generally below the Chipeta or Persayo soils. The depth to shale is 20 to 40 inches. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is grayish-brown, slightly saline, strongly calcareous, hard clay loam about 9 inches thick. The underlying material is light brownish-gray, slightly and moderately saline clay loam or shaly silty clay loam. Light brownish-gray weathered shale bedrock is at a depth of about 29 inches.

The Killpack soils are used for range, cultivated crops, and irrigated pasture. Crops grown under irrigation are alfalfa, corn, small grains, and sugar beets, but the soils are not well suited to these crops nor to irrigated pasture.

Representative profile of a Killpack clay loam in a cultivated field, 2,450 feet north and 300 feet east of the SW. corner of section 30, T. 16 S., R. 10 E., in Emery County, Utah:

Ap—0 to 9 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium and fine, granular structure; hard, firm, slightly sticky and slightly plastic; plentiful fine roots; common fine pores; strongly calcareous; mildly alkaline (pH 7.8); clear, smooth boundary.

C1—9 to 23 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) when moist; moderate, coarse, subangular blocky structure breaking to weak, fine, subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual, wavy boundary.

C2es—23 to 29 inches, light brownish-gray (2.5Y 6/2) shaly silty clay loam, grayish brown (2.5Y 5/2) when moist; massive; hard, very firm, sticky and plastic; few fine roots; no pores; strongly calcareous; many gypsum crystals 5 to 15 millimeters in diameter; mildly alkaline (pH 7.7); gradual, wavy boundary.

R—29 inches +, light brownish-gray (2.5Y 6/2) weathered shale.

Except where they are irrigated, Killpack soils generally are dry when not frozen. Clay minerals are mixed, but dominantly they are illite and kaolinite. In the A1 horizon, hue ranges from 10YR to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; and chroma is 2 or 3. The part of the profile between 10 inches and bedrock is silty clay loam to clay loam that contains less than 35 percent clay. The hue in this part ranges from 10YR to 5Y; value is 6 or 7 when the soils are dry and ranges from 4 to 6 when they are moist; and chroma is 2 or 3. The C2cs horizon contains 5 to 20 percent shale fragments. A weak to moderate accumulation of gypsum immediately overlies the shale.

**Killpack clay loam, 1 to 3 percent slopes** (KlB).—The profile of this soil is the one described as typical of the series. Included in mapping were small areas in which the soil is thicker than 40 inches and places where it is less than 20 inches thick over shale. Also included were small areas of strongly and very strongly saline soils, and a small area south and west of Moore in which the soil is brown above a depth of 24 inches.

Drainage is good, and permeability is slow. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale, and then they spread horizontally. About 4 to 5 inches of water is retained by this soil, but only about 2 to 2.5 inches, the amount depending on the depth to shale, is readily available to plants. This soil is hard to work, and generally it is hard to irrigate. The seedbed is more easily prepared if this soil is plowed in fall when it is barely moist, and is allowed to remain rough over winter, than when it is plowed in spring.

This soil is used for spring and fall range, for irrigated pasture, and for irrigated alfalfa and small grains. The growing season is only long enough for two full crops of alfalfa and for part of a third to mature. (Capability units IVe-25, irrigated, and VIIs-D, nonirrigated; Desert Loam Bottom range site)

**Killpack clay loam, 3 to 6 percent slopes, eroded** (KlC2).—This soil is steeper and more eroded than the one for which a profile is described as typical for the series. Included in mapping were small areas of clayey soils and some areas in which the soils are deeper than 40 inches over shale. Also included were places, generally near the shaly colluvial slopes, where gravel is on the surface and in the surface layer.

This Killpack soil is fairly close to nearly bare shale hills that contribute considerable runoff. Runoff is rapid, and the susceptibility to erosion is high. Gullies 3 to 6 feet deep and 100 to 300 feet apart are common. In some places most of the surface layer has been lost through sheet erosion.

This soil is used mainly for range. It is also used for alfalfa, small grains, and pasture crops grown under irrigation, but it is not well suited to those uses. (Capability units VIe-23, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom range site)

**Killpack loam, 1 to 3 percent slopes** (KpB).—The profile of this soil is similar to the one described as typical of the series, except that the surface layer is heavy loam, and the subsoil below a depth of 15 to 24 inches is light silty clay loam to light silty clay. In addition, the gypsum horizon is less prominent.

Included in mapping were small areas in which the surface layer is clay loam.

This Killpack soil is easy to work, and it absorbs water readily. The area that is cultivated and irrigated is limited in extent and is used for alfalfa, small grains, corn, and pasture. (Capability units IVe-25, irrigated, and VIIc-D, nonirrigated; Desert Loam Bottom range site)

**Killpack loam, 3 to 6 percent slopes, eroded** (KpC2).—The profile of this soil is similar to the one described as typical of the series, except that the surface layer is heavy loam and the subsoil below a depth of 15 to 24 inches is silty clay loam or light silty clay.

Included in mapping were areas of deep loam and silty clay loam.

This Killpack soil is on the side slopes of shale hills. Runoff is rapid, sheet erosion is active, and the susceptibility to erosion is high. Near bare shale hills, this soil contains gullies 3 to 6 feet deep and 100 to 300 feet apart. This soil absorbs water readily. It is easy to till and cultivate but is difficult to irrigate.

Most areas of this soil are in native range. Areas that are cultivated and irrigated are limited in extent and are used mainly for alfalfa and pasture. Controlling erosion is an important management requirement. (Capability units VIe-23, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom range site)

## Killpack Series, High Watertable Variant

In the Carbon-Emery Area, the high watertable variant of the Killpack series differs from the typical members of this series in that it is a mottled or gleyed clay loam that has a high water table.

Representative profile of Killpack clay loam, in a pasture 2,300 feet north and 560 feet east of the SW. corner of section 5, T. 18 S., R. 9 E., in Emery County, Utah:

O1—1 inch to 0, organic layer consisting mainly of grass roots; strongly calcareous; moderately saline; grass stems close to the ground are encrusted with salt and carbonates; moderately alkaline (pH 8.4); abrupt, smooth boundary.

A1—0 to 4 inches, grayish-brown (2.5Y 5/2) clay loam; dark grayish brown (2.5Y 4/2) when moist; weak, medium, granular structure; hard, firm, sticky and plastic; abundant fine and very fine roots; common fine pores; strongly calcareous; moderately alkaline (pH 8.2); clear, smooth boundary.

C1—4 to 20 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) when moist; massive; hard, firm, sticky and plastic; plentiful fine and very fine roots; few fine pores; strongly calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

C2—20 to 30 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) when moist; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; hard, firm, sticky and very plastic; few fine roots; few very fine pores; strongly calcareous; strongly alkaline (pH 8.6); few salt or gypsum crystals; gradual, smooth boundary.

C3cs—30 to 39 inches, gray (2.5Y 6/1) shaly silty clay loam, dark gray (2.5Y 4/1) when moist; common, medium, distinct, yellowish-brown (10YR 5/4) mottles; massive; hard, very firm, sticky and plastic; about 20 percent shale fragments; few fine roots; no pores; strongly calcareous; strongly alkaline (pH 8.6); numerous soft gypsum nodules 5 to 15 millimeters in diameter; clear, smooth boundary.

R—39 inches +, soft marine shale bedrock.

**Killpack clay loam, high watertable variant, 1 to 3 percent slopes** (KmB).—This soil is the only variant of the Killpack series mapped in this survey area. Its profile is the one described as typical of the high water table variant of the Killpack series.

This soil generally occurs in small, low areas that receive seep water from canals or irrigation ditches higher on the slope. It has a water table at a depth between 20 and 36 inches, generally above the shale. Mottles are typically at a depth between 20 and 30 inches, but in places they are only 6 inches from the surface. Salinity

is strongest near the surface, and it ranges from moderate to strong.

Drainage is poor, and permeability is slow. Runoff is slow, and the susceptibility to erosion is slight. Roots penetrate only to the shale, and then they spread horizontally. This soil is not extensive, nor is it important for farming. It is suited to and is used for grazing. (Capability unit VIw-2, nonirrigated; Wet Meadow range site)

## Libbings Series

The Libbings series consists of poorly drained, moderately fine textured, very strongly saline, gently sloping soils that are moderately deep over shale. These soils are typically at the bases of slopes below the Chipeta and Persayo soils, in areas where irrigation water or seepage from canals causes salts to accumulate. They developed in residuum and in local alluvium derived from shale. The vegetation is mainly greasewood and saltgrass. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is platy or granular grayish-brown silty clay loam about 2 inches thick. The underlying material is light brownish-gray and gray silty clay loam to clay that extends to shale bedrock. Bedrock is at a depth of about 34 inches.

The Libbings soils are used only for range.

Representative profile of Libbings silty clay loam, in a range area, 330 feet south and 160 feet east of the NW. corner of section 8, T. 17 S., R. 10 E., in Emery County, Utah:

A11sa—0 to ½ inch, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, thick, platy structure breaking to moderate, fine, granular structure; hard, friable, sticky and plastic; no roots; many very fine vesicular pores; strongly calcareous, very strongly saline; thin salt crust on surface; strongly alkaline (pH 8.5); abrupt, smooth boundary.

A12sa—½ inch to 2 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, fine, granular structure; soft, firm, sticky and plastic; few very fine roots; many very fine vesicular pores; strongly calcareous; very strongly saline and contains very fine salt grains or crystals; strongly alkaline (pH 8.9); abrupt, smooth boundary.

C1sa—2 to 9 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, granular structure; very hard, very firm, sticky and very plastic; few fine and very fine roots; few fine and very fine, discontinuous pores; strongly calcareous; very strongly saline; efflorescent salt on some peds and in pores; strongly alkaline (pH 8.6); clear, smooth boundary.

C2sacs—9 to 25 inches, gray (2.5Y 6/1) clay, dark gray (2.5Y 4/1) when moist; massive; very hard, very firm, sticky and very plastic; few medium and fine roots; few, very fine, discontinuous pores; strongly calcareous; very strongly saline; plentiful salt and gypsum nodules; strongly alkaline (pH 8.6); gradual, smooth boundary.

C3sacs—25 to 34 inches, gray (2.5Y 6/1) silty clay, dark gray (2.5Y 4/1) when moist; massive; very hard, very firm, sticky and plastic; few very fine roots; few, very fine, discontinuous pores; strongly calcareous; numerous soft gypsum nodules 5 to 15 millimeters in diameter; 5 to 10 percent shale fragments; strongly saline; strongly alkaline (pH 8.7); clear, smooth boundary.

R—34 inches +, soft, platy shale. Roots and water concentrated between shale plates.

The water table is at a depth between 10 and 30 inches. The content of salt above a depth of 20 inches ranges from 2 to 5 percent. Exchangeable sodium ranges from 50 to 65 percent. It is greatest near the surface, and it decreases with depth below 20 inches. Reaction is strongly to very strongly alkaline. Shale is at a depth of 20 to 40 inches. In the A1 horizons, hue ranges from 10YR to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; chroma is 2. The part of the profile between 10 inches and shale is mainly silty clay, but the texture ranges from heavy silty clay loam to clay and contains more than 35 percent clay. Hue in this part ranges from 1Y to 5Y; value is 5 or 6 when the soils are dry and 4 or 5 when they are moist; chroma is 1 or 2. In the Ccs horizons, the accumulation of gypsum ranges from weak to moderate, and there typically is 2 to 7 percent more gypsum in these horizons than in the underlying shale. From 5 to 25 percent of the horzion immediately above the shale is slightly weathered fragments of shale.

The Libbings soils occur with the Saltair, Chipeta, Killpack, Billings, and Cache soils.

**Libbings silty clay loam** (0 to 3 percent slopes) (Lb).—The profile of this soil is the one described as typical of the series. The surface layer is only ¼ to ½ inch thick. It has a platy structure but typically breaks to granules containing numerous crystals of salt. The layer over the shale contains numerous crystals of gypsum or salt, but in some places these crystals are not present.

Included in mapping were minor areas in which shale is at a depth of more than 40 inches, and some areas in which the shale is at a depth of less than 20 inches. Also included were some areas of saline soils that contain less than 2 percent salt.

Drainage is poor, and permeability is slow above the shale. Runoff is medium, and this soil is moderately susceptible to erosion. The water table is 10 to 30 inches below the surface, and is highest early in summer. Mottles occur in some places. Water spreads horizontally on top of the shale and penetrates to a depth of only a few inches. In some places water moves freely between the plates of shale. Roots penetrate to the shale, and then they spread horizontally.

This soil is used for grazing. (Capability unit VIIw-28, nonirrigated; Salt Meadow range site)

**Libbings silty clay loam, barren** (0 to 3 percent slopes) (Ls).—The profile of this soil is similar to the one described as typical of the series, except that it has a greater accumulation of salt, especially in the surface layer. Salt crusts ½ inch to 1½ inches thick are common on the surface. This soil is mostly in depressions, where drainage is severely restricted. It is flooded occasionally and receives salty seepage water. Water is removed mainly by evaporation, and the salt accumulates. The surface is bare.

Areas of this soil are not suitable for grazing. (Capability unit VIIIw-8, nonirrigated; not rated for other uses)

## Minchey Series

The Minchey series consists of deep, well-drained, moderately fine textured, nearly level or gently sloping soils

on benches and mesas. They have formed in glacial outwash derived mostly from sandstone and quartzite. The vegetation is galletagrass, black sage, and Indian ricegrass. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 7 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is pale-brown loam about 3 inches thick. The underlying material is mainly brown or pale-brown clay loam or sandy clay loam, and a very pale brown, thick, limy layer is below it. Pale-brown and light yellowish-brown gravelly sandy loam is below a depth of 32 inches. Gravel and cobblestones are typical at a depth between 2 and 5 feet.

These soils are cultivated if water for irrigation can be obtained. Under irrigation, they are used for alfalfa, small grains, corn, and pasture. The soils are fairly well suited to these uses. If not cultivated, they are used for range.

Representative profile of a Minchey loam on a mesa, 1,980 feet south and 140 feet west of the NE. corner of section 9, T. 16 S., R. 10 E., in Emery County, Utah:

A1—0 to 3 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak, thin, platy structure; soft friable, slightly sticky and slightly plastic; few fine and medium roots; vesicular pores; moderately calcareous; moderately alkaline (pH 8.2); clear, smooth boundary.

C1—3 to 12 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; moderate, medium, subangular blocky structure; hard, firm, slightly sticky and plastic; few medium and fine roots; many medium pores; moderately calcareous; moderately alkaline (pH 8.0); gradual, wavy boundary.

C2ca—12 to 20 inches, pale-brown (10YR 6/3) clay loam, dark brown (10YR 4/3) when moist; moderate, medium, subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few fine pores; strongly calcareous; lime is in fine nodules and is disseminated; moderately alkaline (pH 8.3); gradual, wavy boundary.

C3ca—20 to 32 inches, very pale brown (10YR 8/3) sandy clay loam, very pale brown (10YR 7/3) when moist; massive; hard, firm, slightly sticky and slightly plastic; few fine and medium roots; very few fine pores; very strongly calcareous; lime is disseminated and is in fine nodules; moderately alkaline (pH 8.2); diffuse, wavy boundary.

C4ca—32 to 48 inches, pale-brown (10YR 6/3) gravelly sandy loam, dark brown (10YR 4/3) when moist; massive; slightly hard, very friable, nonsticky and slightly plastic; few fine roots; few fine pores; strongly calcareous; moderately alkaline (pH 7.9); gradual, wavy boundary.

C5—48 to 64 inches, light yellowish-brown (10YR 6/4) very gravelly sandy loam, yellowish brown (10YR 5/4) when moist; single grain; loose, very friable, nonsticky and slightly plastic; few fine roots; strongly calcareous; moderately alkaline (pH 8.4).

Depth to limy horizons ranges from 10 to 20 inches. The content of carbonates ranges from 15 to 55 percent, but a content of 25 to 40 percent is typical. In the A1 horizon, the hue is 10YR; value ranges from 5 to 7 when the soils are dry and is 4 or 5 when they are moist; and chroma is 2 or 3. Texture in the A1 horizon is loam or clay loam. The part of the profile between 10 and 40 inches is clay loam or sandy clay loam that is less than 35 percent clay and is more than 15 percent sand coarser than very fine sand, according to a weighted average. In places the lower one-third of this section contains as much as 50 percent gravel and cobblestones. In the part between 10 and 40 inches, hue is 7.5YR to 10YR; value ranges from 5 to 8 when the soils are dry and from 4 to 7 when they are moist; and chroma is 3 or 4. Below a depth of 40 inches, the texture ranges from sandy loam to loamy sand. The Minchey soils are generally dry when not frozen, unless they are irrigated.

**Minchey loam, 1 to 3 percent slopes** (MlB).—A profile of this soil is the one described as typical of the series. This soil normally is nonsaline.

Included in mapping were small areas of gravelly soils and of soils similar to this Minchey soil, except that the subsoil is loam or very fine sandy loam.

Drainage is good, and permeability is moderate. Runoff is medium, and the susceptibility to erosion is moderate. Roots generally penetrate deeply, but in places they are restricted by gravel and cobblestones at depths below 20 inches. The soil retains between 8 and 9 inches of water, but only 4.5 to 5.5 inches of water is readily available to plants. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range. In addition, some areas are irrigated and are used for alfalfa, small grains, corn, and pasture. (Capability units IIe–24, irrigated, and VIIc–S, nonirrigated; Semi-Desert Loam Bench range site)

**Minchey clay loam, 1 to 3 percent slopes** (McB).—This soil is similar to the one for which a profile is described as typical for the series except that the surface layer is clay loam and is harder to work. The seedbed is more easily prepared if this soil is plowed in fall when barely moist, and is left rough over winter, than when it is plowed in spring.

This soil is irrigated and is used for alfalfa, small grains, corn, and pasture. (Capability unit IIe–2, irrigated; not rated for other uses)

**Minchey-Sanpete complex, 1 to 3 percent slopes** (MsB).—This mapping unit is composed of Minchey and Sanpete soils so intermixed that they could not be separated in mapping. These soils occupy benches and mesas.

Minchey loam, 1 to 3 percent slopes, in smooth areas, makes up about 80 percent of the complex. Sanpete sandy clay loam, 1 to 3 percent slopes, on low ridges and on the edges of benches, makes up about 20 percent.

Both soils in this mapping unit are used for irrigated crops where water can be supplied. They are fairly hard to work and to irrigate. The main uses of the soils are for alfalfa, corn, small grains, and pasture. Areas of these soils that are not irrigated are used for range. (The Minchey soil is in capability units IIe–24, irrigated, and VIIc–S, nonirrigated. The Sanpete soil is in capability units IVs–24, irrigated, and VIIs–S4, nonirrigated. The Minchey soil is in Semi-Desert Loam Bench range site; the Sanpete soil is in Semi-Desert Limy Loam range site)

**Minchey-Sanpete complex, 1 to 6 percent slopes, eroded** (MsC2).—This mapping unit is about 60 percent Minchey loam, 1 to 3 percent slopes, and 40 percent Sanpete gravelly sandy clay loam, 3 to 6 percent slopes, eroded. The Minchey component has a profile like the one described as typical of the Minchey series. The Sanpete component has a profile similar to the profile described as typical for the Sanpete series, except that it is eroded and is steeper.

The Minchey soil typically is in smooth areas, and the Sanpete typically occupies the ridges and stronger slopes.

In places the whitish subsoil of these soils has been exposed through erosion, and gravel and cobblestones on the surface are coated with lime. This indicates erosion has removed some soil material from around them.

Both soils have an uneven or undulating surface, and they are hard to cultivate and to irrigate. Many areas are used for spring and fall range. Where these soils are irrigated, they are used for alfalfa, small grains, and pasture. (The Minchey soil is in capability units IIe-24, irrigated, and VIIe-S4, nonirrigated; the Sanpete soil is in capability units IVs-24, irrigated, and VIIs-S4, nonirrigated. The Minchey soil is in Semi-Desert Loam Bench range site; the Sanpete soil is in Semi-Desert Limy Loam range site)

**Mixed alluvial land** (Mx) consists of unconsolidated alluvium that is typically stratified and widely variable in texture, color, and consistence. It occurs along stream channels and in most places has been deposited recently by streams. This material is subject to change through periodic overflow, but it has remained in place long enough for plants to have become established. Typically, there has been no development of a soil profile, but in places the soil material near the surface is slightly darkened by organic matter. Drainage generally is restricted, and the soil material is mottled. Small areas in which the material is cobbly or stony are near the mouths of canyons. Away from the canyons, the sediments are finer textured.

This miscellaneous land type has little value for farming, except that it is used for grazing. (Capability unit VIw-2, nonirrigated; Wet Stream Bottom range site)

## Palisade Series

The Palisade series consists of deep, medium-textured, well-drained, nearly level soils on mesas and benches. As a rule, the soils occur in medium to large areas on the lower parts of benches. They have formed in glacial outwash derived from calcareous sandstone mixed with shale and limestone, mainly along the west side of the survey area. Palisade soils are calcareous throughout and have strongly calcareous horizons. The vegetation is mainly galletagrass, shadscale, bud sage, and Indian ricegrass. Elevations range from 5,000 to 6,700 feet. The annual rainfall is 7 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is pale-brown, limy, soft loamy fine sand about 3 inches thick. The underlying material is very pale brown and yellowish-brown very fine sandy loam, and it is strongly calcareous to moderately calcareous. Gravel and cobblestones may occur at depths between 2 and 5 feet.

Under irrigation, the soils are used for alfalfa, small grains, corn, sugar beets, and pasture. A small acreage is in peach and apple orchards. The soils are well suited to these uses. Areas not in cultivation are used for range.

Representative profile of a Palisade very fine sandy loam, 700 feet south and 3,310 feet east of the NW. corner of section 35, T. 15 S., R. 9 E., in Carbon County, Utah:

A1—0 to 3 inches, pale-brown (10YR 6/3) loamy fine sand, dark brown (10YR 4/3) when moist; weak, thick, platy structure; soft, very friable, nonsticky and nonplastic; plentiful fine roots; few fine and many very fine, discontinuous pores; moderately calcareous; moderately alkaline (pH 8.2); clear, smooth boundary.

C1—3 to 8 inches, yellowish-brown (10YR 5/4) very fine sandy loam, dark yellowish brown (10YR 4/4) when moist; weak, medium, subangular blocky structure breaking to weak, fine, subangular blocky structure; slightly hard, firm, slightly sticky and slightly plastic; plentiful fine and few medium roots; common, fine, discontinuous pores and a few medium pores; moderately calcareous; moderately alkaline (pH 8.1); clear, wavy boundary.

C2ca—8 to 18 inches, very pale brown (10YR 7/3) very fine sandy loam, brown (10YR 5/3) when moist; moderate, medium, subangular blocky structure breaking to weak, fine, angular blocky structure; very hard, firm, slightly sticky and plastic; few fine and few medium roots; few large, few medium, and common fine pores; strongly calcareous; moderately alkaline (pH 8.0); gradual, smooth boundary.

C3ca—18 to 29 inches, very pale brown (10YR 7/3) very fine sandy loam, pale brown (10YR 6/3) when moist; weak, medium, angular blocky structure breaking to weak, fine, angular blocky structure; very hard, firm, slightly sticky and slightly plastic; few fine and few medium roots; few large, few medium, and common fine pores; strongly calcareous; moderately alkaline (pH 8.3); gradual, smooth boundary.

C4ca—29 to 41 inches, very pale brown (10YR 7/3) very fine sandy loam, pale brown (10YR 6/3) when moist; weak, medium, subangular blocky structure breaking to weak, fine, subangular blocky structure; hard, firm, nonsticky and slightly plastic; few fine and few medium roots; few large, few medium, and few fine pores; strongly calcareous; strongly alkaline (pH 8.6); gradual, smooth boundary.

C5—41 to 60 inches, light yellowish-brown (10YR 6/4) very fine sandy loam, yellowish brown (10YR 5/4) when moist; massive; hard, friable, slightly sticky and slightly plastic; common fine roots; few large, few medium, and common fine pores; strongly calcareous; strongly alkaline (pH 8.5).

The Palisade soils generally are dry when not frozen, unless they are irrigated. They have a mixed clay mineralogy. In the A horizon, hue is 10YR; value is 5 or 6 when the soils are dry and is 4 or 5 when they are moist; and chroma is 3 or 4. The part of the profile between 10 and 40 inches is very fine sandy loam or light loam that contains less than 18 percent clay and more than 15 percent sand coarser than very fine sand. In places gravel and cobblestones make up as much as 50 percent, by volume, of the lower one-third of this 30-inch section. In the part of the profile between 10 and 40 inches, hue is 7.5YR to 10YR; value ranges from 5 to 7 when the soils are dry and from 4 to 6 when they are moist; and chroma ranges from 2 to 4. The content of calcium carbonate in the limy horizons ranges from 15 to 40 percent. Below a depth of 40 inches, the texture ranges from very fine sandy loam to gravelly loamy sand.

**Palisade very fine sandy loam, 1 to 3 percent slopes** (PdB).—The profile of this soil is the one described as typical of the series. Where this soil has been cultivated, the surface layer is mixed with material from the subsoil and can no longer be recognized. Gravel and cobblestones are between depths of 2 and 5 feet in places.

Included in the mapping were areas of Minchey loam, and places where gravel and cobblestones are at a depth of less than 20 inches. Also included was a small acreage near the Carbon County Airport of a soil that contains a lime-cemented hardpan. Another inclusion, on the Porphyry Bench west of Price, consists of a small acreage of soils in which the surface layer and the subsoil are not calcareous.

Drainage is good, and permeability is moderate. Root

penetration is deep. About 9 inches of water is retained by this soil, but only 4.5 to 5.5 inches is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is easy to work and to irrigate. Leveling is needed in many areas, however, to help obtain the uniform distribution of irrigation water. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range, and for irrigated alfalfa, small grains, corn, and pasture. Because of the short growing season, alfalfa produces only two full crops and part of a third. Corn does not mature for grain and is used for ensilage. Alfalfa needs a large amount of phosphorus. (Capability units IIe–24, irrigated and VIIc-S, nonirrigated; Semi-Desert Loam Bench range site)

**Palisade very fine sandy loam, 3 to 6 percent slopes, eroded** (PdC2).—This soil is similar to the one for which a profile is described as typical for the series, except that it is steeper and is eroded. It occurs in small areas on benches.

Runoff is medium, and the susceptibility to erosion is high. In some areas gullies are 2 to 3 feet deep. Sheet erosion is active in irrigated areas. At the upper end of many fields, the whitish, calcareous subsoil has been exposed through erosion or is only 3 to 4 inches below the surface.

This soil is used for spring and fall range, and for irrigated alfalfa, small grains, and pasture. The control of erosion is needed. Alfalfa and grass mixtures grown for hay or pasture effectively reduce erosion in most places. (Capability units IIIe–2, irrigated, and VIIe–S, nonirrigated; Semi-Desert Loam Bench range site)

## Palisade Series, High Watertable Variant

In the Carbon-Emery Area, this variant of the Palisade series differs from the typical members in that it is a somewhat poorly drained loam that has a high water table. This variant occupies small, low areas on benches. It receives seep water from canals, ditches, and irrigated land higher on the slope. The vegetation is wiregrass, sedge, and saltgrass.

Representative profile of a Palisade loam, high watertable variant, in a pasture, 2,600 feet south and 2,500 feet west of the NE. corner of section 20, T. 22 S., R. 6 E., in Emery County, Utah:

A1—0 to 6 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; many, medium, distinct, strong-brown (7.5YR 5/6) mottles; weak, medium to fine, angular blocky structure; slightly hard, friable, slightly sticky and plastic; abundant medium and fine roots; common medium and fine pores; strongly calcareous; mildly alkaline (pH 7.5); clear, smooth boundary.

AC—6 to 17 inches, light brownish-gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) when moist; medium, distinct, strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; plentiful medium and fine roots; strongly calcareous; mildly alkaline (pH 7.7); clear, smooth boundary.

C1—17 to 23 inches, very pale brown (10YR 7/3) fine sandy loam, brown (10YR 5/3) when moist; many, medium, distinct, strong-brown (7.5YR 5/6) mottles; slight gleying along root channels; weak, medium, angular blocky structure; slightly hard, very friable, nonsticky and nonplastic; plentiful medium and fine roots; common fine pores; moderately calcareous; mildly alkaline (pH 7.8); clear, wavy boundary.

C2—23 to 36 inches, very pale brown (10YR 7/3) very fine sandy loam, brown (10YR 5/3) when moist; common, fine, distinct, strong-brown (7.5YR 5/6) mottles and plentiful, medium, distinct, dark-gray (N 4/0) mottles; massive; slightly hard, very friable, nonsticky and nonplastic; few medium and common fine pores; moderately calcareous; moderately alkaline (pH 8.0); gradual, wavy boundary.

C3ca—36 to 47 inches, very pale brown (10YR 7/3) gravelly sandy clay loam, brown (10YR 5/3) when moist; few, fine, distinct, strong-brown (7.5YR 5/6) mottles and few, medium, distinct, dark-gray (N 4/0) mottles; massive; hard, friable, slightly sticky and slightly plastic; few medium roots; common fine pores; strongly calcareous; moderately alkaline (pH 8.0); gradual, irregular boundary.

C4—47 to 60 inches, very pale brown (10YR 7/4) gravelly loamy sand, light yellowish brown (10YR 6/4) when moist; single grain; loose, nonsticky and nonplastic; few medium roots; no pores; moderately calcareous; moderately alkaline (pH 8.3).

**Palisade loam, high watertable variant, 1 to 3 percent slopes** (PaB).—This soil is the only variant of the Palisade series mapped in the survey area. Its profile is the one described as typical of the high watertable variant of the Palisade series.

This soil occurs only on a few irrigated farms, where it occupies small, low areas on benches that receive run-in water and seep water from canals, irrigation ditches, and irrigated fields higher on the slope. The water table is at a depth between 10 and 45 inches, but generally it is between depths of 20 and 30 inches. Mottles typically are at a depth of less than 20 inches. Gravel and cobblestones generally are at some depth between 2 and 5 feet. In places a moderate amount of salt has accumulated. The vegetation is wiregrass, sedge, and saltgrass.

Included in the mapping was a small area of clay loam on the bench north of Castle Dale. Also included were small areas of a soil that has moderate slopes.

Drainage is somewhat poor, and permeability is moderate. Runoff is slow, and the susceptibility to erosion is low. Natural fertility is moderate. Root penetration is moderately deep or deep, depending on the depth to gravel, cobblestones, and the water table. Grass roots and plants residue have considerably increased the content of organic matter in this soil.

This soil needs to be drained if it is cropped. No drainage experience is available, but indications are that the soil would not be difficult to drain and to reclaim. This soil is used only for pasture. (Capability unit Vw–2W, nonirrigated; Wet Meadow range site)

## Penoyer Series

The Penoyer series consists of well-drained, calcareous soils that are medium textured. These soils occupy medium to large areas of alluvial fans, flood plains, and alluvial plains on the bottoms of canyons. They have formed in alluvium from sandstone, limestone, and basic igneous rocks. The natural vegetation is mainly sagebrush, Indian ricegrass, galletagrass, and shadscale. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous loam about 9 inches thick. The underlying material is light brownish-gray loam and very fine sandy loam.

Nearly all areas of Penoyer soils have been cleared and are planted to crops. The soils are used mainly for alfalfa, small grains, corn, sugar beets, melons, and irrigated pasture. Where air drainage is favorable for reducing the frost hazard, these soils are used for apple orchards.

Representative profile of a Penoyer loam in a cleared area, 650 feet south and 100 feet west of the NE. corner of section 24, T. 18 S., R. 7 E., in Emery County, Utah:

Ap1—0 to 4 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, platy structure breaking readily to moderate, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; plentiful medium roots; many fine and few large pores; strongly calcareous; mildly alkaline (pH 7.7); clear, smooth boundary.

Ap2—4 to 9 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; plentiful medium roots; few large and few fine pores; strongly calcareous; mildly alkaline (pH 7.7); clear, smooth boundary.

C1—9 to 23 inches, light brownish-gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, angular blocky structure breaking readily to weak, medium, subangular blocky structure; hard, very friable, slightly sticky and slightly plastic; many fine and few medium roots; strongly calcareous; moderately alkaline (pH 7.9); gradual, wavy boundary.

C2—23 to 41 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; massive; hard, very friable, nonsticky and nonplastic; few fine roots; common, fine, discontinuous pores; strongly calcareous; moderately alkaline (pH 8.0); gradual, wavy boundary.

C3—41 to 60 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard to hard, very friable, nonsticky and nonplastic; few fine roots; few fine pores; strongly calcareous; moderately alkaline (pH 8.2).

Penoyer soils generally are dry when not frozen, unless they are irrigated. The content of calcium carbonate ranges from 5 to 25 percent. Reaction ranges from mildly to moderately alkaline. Salinity ranges from slight to moderate. Clay mineralogy is mixed, but the clay is dominantly montmorillonite. In the A horizons, hue is 10YR; value is 6 or 7 when the soils are dry and is 4 or 5 when they are moist; and chroma is 2 or 3. The texture of the A horizons ranges from very fine sandy loam to silty clay loam. In the part of the profile between 10 and 40 inches, the texture is light loam, silt loam, or very fine sandy loam, and the soil contains less than 18 percent clay and less than 15 percent sand coarser than very fine sand. All of the upper 40 inches is about the same color. Below a depth of 40 inches, the texture ranges from clay loam to sandy loam.

**Penoyer loam, 1 to 3 percent slopes** (PeB).—The profile of this soil is the one described as typical of the series. The subsoil is typically loam or very fine sandy loam. Below a depth of 40 inches, this soil is weakly stratified with clay loam to sandy loam. In places gypsum veining and olive colors are below a depth of 3 to 4 feet.

Included in the mapping were small areas of Penoyer silt loam and of Penoyer silty clay loam, and small areas of olive-brown or brownish-gray soils. Also included east of Wellington and south of Helper were a few small spots underlain by gravel at some depth below 20 to 30 inches. Other inclusions consist of a few areas that are underlain by gravel and in the bottoms of canyons. In some places soils are included that have slopes of slightly less than 1 percent.

Drainage is good, and permeability is moderate. Roots penetrate deeply. This soil retains about 12 inches of water, but only about 5 inches of water is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is easy to work and to irrigate. It has the highest natural fertility of any soil in the survey area, and it is most responsive to management. Land leveling is needed in a few areas. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, corn, and sugar beets. Because of the short growing season, alfalfa produces only two full crops and sometimes part of a third crop each year. Corn does not mature for grain and is used for ensilage. (Capability units IIe-2, irrigated, and VIIc-D, nonirrigated; Desert Loam Bottom range site)

**Penoyer loam, 3 to 6 percent slopes, eroded** (PeC2).—This soil is similar to the one for which a profile is described as typical of the series, except that it has stronger slopes and is eroded. Included in mapping were minor areas of gravelly soils and of soils similar to the Penoyer, except that they have an olive or brownish-gray color.

Runoff is medium, and the susceptibility to erosion is high. Sheet erosion is moderately active. Many areas contain rills and shallow gullies.

This soil is used for irrigated pasture, alfalfa, and small grains. Many areas are used for spring and fall range. (Capability units IIIe-2, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom range site)

**Penoyer loam, 1 to 10 percent slopes, channeled** (PhD).—This soil is limited in extent, and all of the acreage is near Green River. The surface is an uneven series of low ridges and hollows. Gullies that are now fairly well stabilized have dissected and channeled the areas. Extensive leveling is needed before this soil can be cultivated. Runoff is rapid, and the susceptibility to erosion is high.

Before it was channeled and dissected, this soil was similar to the one for which a profile is described for the series, except that it was steeper in places. It is used only for range. (Capability unit VIIe-D, nonirrigated; Desert Loam Bottom range site)

**Penoyer loam, extended season, 0 to 1 percent slopes** (PnA).—This soil is similar to the one for which a profile is described as typical of the series, except that it is nearly level and is near Green River, where the growing season is 140 to 160 days.

Included in mapping were soils that have slopes of 1 to 2 percent and some soils that have slopes of 3 to 6 percent. Included also were minor areas of soils that have a silty clay loam surface layer and a sandy loam subsoil.

Land leveling has been done in many fields, but it is still needed in some areas to improve the distribution of irrigation water. Runoff is slow, and the susceptibility to erosion is slight.

This soil is used for irrigated pasture, alfalfa, small grains, corn, melons, and sugar beets. Alfalfa produces

three full cuttings a year, and corn matures for grain. (Capability unit I-1, irrigated; not rated for other uses)

**Penoyer silty clay loam, 1 to 3 percent slopes** (PoB).—This soil has a surface layer 8 to 14 inches thick. Included with it in the mapping were small areas of Penoyer loam and of Ravola loam. Also included were about 100 acres along Ferron Creek, west of Ferron, in which the subsoil below a depth of 11 to 15 inches has more fine sand than is typical of a Penoyer soil.

The rate of infiltration is slow. This soil is fairly hard to work. A seedbed is more easily prepared if the soil is plowed in fall when it is barely moist, and is allowed to remain rough over winter, than when it is plowed in spring.

This soil is used for irrigated pastures, alfalfa, small grains, corn and sugar beets. Some areas are used for range. (Capability units IIe-2, irrigated, and VIIs-D, nonirrigated; Desert Loam Bottom range site)

**Penoyer silty clay loam, extended season, 0 to 1 percent slopes** (PrA).—The surface layer of this soil is 8 to 14 inches thick. Otherwise, this soil is similar to the one for which a profile is described as typical of the series.

Included in mapping were areas of soils that have slopes of 1 to 2 percent.

Runoff is slow, and the susceptibility to erosion is slight. The rate of infiltration is moderate to slow. This soil is fairly hard to work. A seedbed is more easily prepared if the soil is plowed in fall when barely moist, and is allowed to remain rough over winter, than when it is plowed in spring.

This soil is used for irrigated pasture, alfalfa, small grains, corn, melons, and sugar beets. The growing season at Green River is 140 to 160 days, or long enough for corn to mature for grain and for alfalfa to produce three full cuttings a year. (Capability unit I-1, irrigated; not rated for other uses)

**Penoyer very fine sandy loam, 1 to 3 percent slopes** (PsB).—This soil is similar to the one described as typical for the series, except for the texture of its surface layer. It is mainly in narrow valleys in the southern part of the survey area, near Ivie and Quitchupah Creeks.

Included in mapping were areas, less than one-half acre in extent, of fine sand that are shallow over shale and sandstone. Also included were small areas of Ravola loam.

Runoff is slow, and the susceptibility to wind erosion is moderate. Hummocks 6 to 12 inches high have formed in some areas. In places head cutting is active and deep gullies have formed.

This soil is used for range and for irrigated pasture, alfalfa, small grains, and corn. (Capability units IIe-2, irrigated, and VIIc-D, nonirrigated; Desert Sandy Loam range site)

**Penoyer very fine sandy loam, 3 to 6 percent slopes, eroded** (PsC2).—This soil is similar to the one for which a profile is described as typical of the series, except that it is steeper, has a coarser textured surface layer, and is eroded. It occupies alluvial fans, generally near the bases of mesas.

Included in mapping were areas, less than one-half acre in extent, of fine sands that are shallow over shale and sandstone.

Runoff is medium, and the susceptibility to erosion is high. Many areas are dissected by a few deep gullies. Hummocks 6 to 12 inches high occur in areas used for range. The available water capacity is about 7.5 inches.

This soil is used mainly for spring and fall range. Some areas, however, are used for irrigated grain and alfalfa or mixtures of alfalfa and grass. (Capability units IIIe-2, irrigated, and VIIe-D6, nonirrigated; Desert Sandy Loam range site)

**Penoyer very fine sandy loam, alkali, 1 to 3 percent slopes, eroded** (PvB2).—This soil is similar to the one for which a profile is described as typical of the series, except that the surface layer has a coarser texture and is moderately affected by alkali. In addition, this soil is eroded and below a depth of 6 inches is strongly affected by alkali. This soil is in the central parts of narrow valleys and is moderately dissected by a few deep gullies. Some slickspots occur. This soil retains about 7.5 inches of water available to plants.

Runoff is high, and it causes moderate sheet and gully erosion. This soil is used mainly for range. Small acreages are used for irrigated grains and alfalfa. (Capability units IVs-28, irrigated, and VIIe-D6, nonirrigated; Desert Sandy Loam range site)

## Persayo Series

Soils of the Persayo series are calcareous, well drained, gently sloping to steep, and moderately fine textured. They occur on hills and have formed in residuum that weathered from shale. The vegetation is mainly galleta-grass and shadscale. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature ranges from 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray loam about 1 inch thick. The underlying material is light brownish-gray loam and silty clay loam that contains a weak to moderate gypsum horizon. Shale bedrock is at a depth of about 12 inches.

Persayo soils are used mainly for spring and fall range. (fig. 12).

Representative profile of a Persayo loam in a range area, 840 feet south and 100 feet east of the NW. corner of section 26, T. 17 S., R. 9 E., in Emery County, Utah:

A1—0 to 1 inch, light brownish-gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) when moist; weak, thin, platy structure breaking to moderate, very fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many fine pores; strongly calcareous; mildly alkaline (pH 7.7); clear, smooth boundary.

C1—1 to 3 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, thin, platy structure; slightly hard, firm, slightly sticky and slightly plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual, smooth boundary.

C2cs—3 to 8 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, moderately thick, platy structure; hard, firm, sticky and plastic; common fine roots; few, fine, discontinuous pores; many fine gypsum crystals and mycelialike veins; 5 percent weathered shale; strongly calcareous; mildly alkaline (pH 7.5); gradual, irregular boundary.

*Figure 12.*—**Indian ricegrass, sand dropseed, and galletagrass on a Persayo very fine sandy loam.**

C3cs—8 to 12 inches, light brownish-gray (2.5Y 6/2) very shaly silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, moderately thick, platy structure; hard, firm, sticky and plastic; few fine roots; many fine gypsum crystals or nodules; 70 percent of horizon is weathered shale fragments; strongly calcareous; mildly alkaline.

R—12 inches +, slightly weathered shale.

As a rule, Persayo soils are dry when not frozen, unless they are irrigated. In the A1 horizon, hue ranges from 2.5Y to 5Y; value is 6 or 7 when the soils are dry and is 4 or 5 when they are moist; and chroma is 2. The part of the profile below 10 inches is silty clay loam that contains less than 35 percent clay. Weathered fragments of shale make up 5 to 70 percent of the material in this part of the profile, and the proportion of fragments of shale increases with depth. All of the upper 20 inches has about the same color. In the C3cs horizon, the content of gypsum ranges from 0.5 to 10 percent and gypsum crystals are few to common.

Persayo soils occur with the Chipeta soils.

**Persayo-Chipeta association, 1 to 20 percent slopes, eroded** (PCE2).—About 60 percent of this mapping unit is Persayo loam, 1 to 20 percent slopes, eroded, and 40 percent is Chipeta silty clay loam, 3 to 20 percent slopes, eroded. These soils are intermingled and occur in no identifiable pattern. The Chipeta soil generally is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were areas of 1 to 5 acres made up of a very strongly saline soil and of areas of a moderately deep soil. Also included was an area of about 200 acres, 5 miles east of Castle Dale, of a brown soil that is similar to the Persayo component mapped in this unit.

The Persayo soil has the profile described as typical of the series. It is well drained and has moderate permeability. Roots penetrate to the shale, and then they spread horizontally. This soil holds 1 to 3 inches of available water, the amount depending on the depth to bedrock. Runoff is medium, and the susceptibility to erosion is moderate.

The Chipeta soil has a profile similar to the one described as typical for the Chipeta series, except that the slopes are stronger and it is eroded. Rill and gully erosion are active.

The soils in this mapping unit are used mainly for spring and fall range, but in places they are used for irrigated pasture. Sheet erosion is active, and in many places shallow gullies have cut into the shale bedrock. (The Persayo soil is in capability unit VIIe–D4, nonirrigated; Desert Loamy Shale range site. The Chipeta soil is in capability unit VIIe–D3, nonirrigated; Desert Shale range site)

## Rafael Series

The Rafael series consists of deep, moderately fine textured, poorly drained soils that are moderately to strongly saline. These soils occur in areas of small to moderate extent on alluvial fans, on flood plains, and in narrow alluvial valleys where water accumulates. They have formed in alluvium derived from marine shale. Vegetation is mainly wiregrass, sedge, redtop grass, and saltgrass. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is light brownish-gray, hard silty clay loam and loam about 11 inches thick. The underlying material is grayish-brown silty clay loam stratified with layers of clay loam or loam. At a depth of less than 20 inches, mottles occur and the amount of exchangeable sodium exceeds 15 percent. At depths of more than 20 inches, the amount of exchangeable sodium decreases.

Rafael soils are used for pasture or for growing meadow hay.

Representative profile of Rafael silty clay loam in a pasture, 1,300 feet west and 600 feet north of the SE. corner of section 29, T. 22 S., R. 6 E., in Emery County, Utah:

A11—0 to 3 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; weak, thin, platy structure; slightly hard, firm, sticky and plastic; plentiful medium and fine roots; few fine and few medium pores; strongly calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

A12—3 to 11 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; common, medium, distinct, yellowish-red (5YR 5/8) mottles; weak, moderately thick, platy structure; hard, firm, sticky and plastic; plentiful medium and few fine roots; common medium and few fine pores; moderately calcareous; moderately alkaline (pH 8.4); clear, wavy boundary.

C1g—11 to 17 inches, grayish-brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) when moist; common, medium, distinct, strong-brown (7.5YR 5/6) and few, fine, faint, gray (N 6/0) mottles; weak, coarse, subangular blocky structure; slightly hard or hard, firm, slightly sticky and plastic; plentiful medium and fine roots; common medium and fine pores; strongly calcareous; strongly alkaline (pH 8.6); clear, wavy boundary.

C2g—17 to 33 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; few, fine, distinct, strong-brown (7.5YR 5/6) mottles and common, medium, distinct, gray (N 6/0) mottles; weak, coarse, prismatic structure breaking to weak, coarse, subangular blocky structure; very hard, very firm, sticky and very plastic; plentiful medium and fine roots; few medium and common fine pores; numerous gypsum mycelia; strongly calcareous; strongly alkaline (pH 8.6); clear, wavy boundary.

C3g—33 to 43 inches, grayish-brown (2.5Y 5/2) heavy loam, dark grayish brown (2.5Y 4/2) when moist; fine, distinct, strong-brown (7.5YR 5/6) mottles and common, medium, distinct, gray (N 6/0) mottles; massive; hard, firm, slightly sticky and plastic; few medium and fine roots; common fine and few medium pores; moderately calcareous; moderately alkaline (pH 8.3); gradual, wavy boundary.

C4g—43 to 70 inches, light brownish-gray (2.5Y 6/2) heavy loam, dark grayish brown (2.5Y 4/2) when moist; common, medium, gray (N 6/0) mottles; massive; hard, firm, slightly sticky and plastic; few medium and fine roots; common fine and few medium pores; strongly calcareous; moderately alkaline (pH 8.2).

The content of lime ranges from 10 to 30 percent and is greatest near the surface. In the A1 horizons, hue is 2.5Y to 5Y; value ranges from 5 to 7 when the soils are dry and is 4 or 5 when they are moist; and chroma is 2 or 3. Distinct to prominent mottles are at depths of less than 20 inches. Gley colors are common in some areas at some depth below 36 inches. Thin layers of peaty material are on the surface in some areas. The part of the profile between 10 and 40 inches is silty clay loam to heavy loam, and contains 22 to 38 percent clay and less than 15 percent sand that is coarser than very fine sand. All of the upper 40 inches is about the same color.

**Rafael silty clay loam** (1 to 3 percent slopes) (Ra).—The profile of this soil is the one described as typical of the series. Distinct mottles typically are in the surface layer, but they are at a depth of as much as 20 inches in some places. Below 3 feet gleying increases with depth. The wettest areas commonly have a thin platy layer on the surface. This soil is moderately to strongly affected by salinity and is not affected to strongly affected by alkali.

Included in mapping were areas of Ferron silt loam. Also included were areas where the soil is strongly saline.

Drainage is poor, and permeability is slow. Roots penetrate deeply, but in most places they are concentrated in the surface layer and in the subsoil. Runoff is slow, and the susceptibility to erosion is slight. Fertility is increased by the high content of organic matter in the surface layer.

This soil is used for grazing. Some of the drier areas are used for growing meadow hay. (Capability unit VIIw–28, nonirrigated; Wet Meadow range site)

## Ravola Series

The Ravola series consists of soils that are deep, medium textured, moderately permeable, and well drained. These soils occupy moderate to large areas on alluvial fans, on flood plains, and in narrow alluvial valleys. They have formed in alluvium that washed from shale and sandstone. The vegetation is mainly galletagrass, shadscale, and some greasewood. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, slightly hard, moderately calcareous loam about 9 inches thick. The underlying material is light brownish-gray, moderately to strongly calcareous loam that in places is weakly stratified with layers of sandy loam or clay loam.

Nearly all areas have been cleared and are used for irrigated pasture, alfalfa, small grains, and corn. Some areas in the mouths of canyons, where air drainage is good enough to reduce the hazard of frost, are used for apple and peach orchards. Areas not cultivated are used for range.

Representative profile of a Ravola loam in a cultivated field, 2,000 feet west and 600 feet north of the SE. corner of section 31, T. 17 S., R. 9 E., in Emery County, Utah:

Ap1—0 to 6 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, subangular blocky structure breaking to weak, fine, subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; plentiful fine and few large roots; common fine and medium continuous pores; moderately calcareous; mildly alkaline (pH 7.8); clear, smooth boundary.

Ap2—6 to 9 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, subangular blocky structure breaking to weak, coarse, granular structure; hard, friable, slightly sticky and slightly plastic; plentiful fine roots; common fine and few medium pores; strongly compacted plowpan layer; moderately calcareous; mildly alkaline (pH 7.7); clear, smooth boundary.

C1—9 to 18 inches, brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, thin, platy structure breaking to weak, very thin, platy structure; hard, friable, slightly sticky and slightly plastic; few large and plentiful fine roots; many large and common fine pores; moderately calcareous; mildly alkaline (pH 7.7); gradual, wavy boundary.

C2—18 to 45 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, subangular blocky structure breaking to weak, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; few large and plentiful fine roots; common large and many fine pores; strongly calcareous; moderately alkaline (pH 7.9); gradual, irregular boundary.

C3—45 to 60 inches, light brownish-gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) when moist; massive; soft, very friable, nonsticky and nonplastic; few fine roots; few fine pores; moderately calcareous; moderately alkaline (pH 7.9).

Ravola soils generally are dry when not frozen, unless they are irrigated. The content of calcium carbonate ranges from 5 to 25 percent. Reaction is mildly and moderately alkaline. Salinity ranges from slight to moderate. The clay mineralogy is mixed, but the clay is mainly illite. In the A horizon, the hue is 2.5Y to 5Y; value is 6 or 7 when the soils are dry and is 4 to 5 when they are moist; and chroma ranges from 2 to 4. In some places the A horizon is silty clay loam. The part of the profile between 10 and 40 inches is heavy loam, silt loam, or very fine sandy loam that contains 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand. All of the upper 40 inches is

about the same color. Below a depth of 40 inches, the texture ranges from sandy loam to silty clay loam.

**Ravola loam, 1 to 3 percent slopes** (RlB).—In most places the profile of this soil is like the one described as typical of the series. In some places, however, the texture between depths of 10 and 40 inches is silt loam to very fine sandy loam and the texture below 40 inches is sandy loam to silty clay loam. Salinity generally is slight to moderate. Alkalinity ranges from none to moderate. Veins of gypsum are common below a depth of 20 to 30 inches. The frost-free season is 110 to 130 days in 3 out of 4 years.

Included in mapping were areas of Billings silty clay loam, and other areas ½ acre to 1 acre in extent, of poorly drained, strongly or very strongly saline-alkali soils. Also included were areas of a soil that is brown or light olive in color, and areas of Ravola loam in which the slopes are slightly less than 1 percent.

Drainage is good, and permeability is moderate. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to a depth of 5 feet or more. This soil retains about 10.5 inches of water, but only about 6 inches of water is readily available to plants. Natural fertility is low, but the fertility in many fields is high because fertilizer has been applied. This soil is easy to work and to irrigate. The uniform distribution of irrigation water is needed. Land leveling can be done with little or no damage to the soil.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, corn, and sugar beets. The growing season is long enough for alfalfa to produce two full cuttings and part of a third. Corn does not mature for grain and is used for ensilage. (Capability units IIe–2, irrigated, and VIIe–D, nonirrigated; Desert Loam Bottom range site)

**Ravola loam, 1 to 3 percent slopes, eroded** (RlB2).—Originally, this soil was similar to Ravola loam, 1 to 3 percent slopes, but erosion has formed V-shaped gullies 4 to 5 feet deep and 100 to 400 feet apart in it. These gullies were caused by runoff from nearly raw shale hills, or in some places by waste water from irrigation. Because of the gullies, some fields are no longer cultivated. The cultivated areas between the gullies are used in the same way as Ravola loam, 1 to 3 percent slopes. Careful use of irrigation water is needed. Areas within 15 to 20 feet of a gully should not be cultivated.

Areas of this soil that are not in cultivation are used for spring and fall range. The cultivated areas are used for irrigated pasture, alfalfa, small grains, and corn. (Capability units IIe–2, irrigated, and VIIe–D, nonirrigated; Desert Loam Bottom range site)

**Ravola loam, 3 to 6 percent slopes, eroded** (RlC2).—This soil is similar to Ravola loam, 1 to 3 percent slopes, except that it has steeper slopes and is eroded. It occupies alluvial fans.

Included in the mapping were similar soils that are moderately deep over shale and some soils that are moderately fine textured.

Runoff is rapid, and the susceptibility to erosion is high. Sheet erosion is active. The surface layer has been washed from the soils in the upper part of most fields and has been deposited on soils in the lower part. In many areas, especially near the steep, nearly bare shale hills, gullies are 4 to 8 feet deep and 100 to 400 feet apart. Some gullies were started by water escaping through breaks in irrigation canals and laterals.

Many areas are used for spring and fall range. The cultivated areas are used for irrigated pasture, grains, and alfalfa. (Capability units IIIe–2, irrigated, and VIIe–D, nonirrigated; Desert Loam Bottom range site)

**Ravola loam, 1 to 10 percent slopes, channeled** (RnD).—This soil has an uneven surface that has been dissected and channeled by gullies that are now fairly well healed. It is limited in extent.

Runoff is rapid, and the susceptibility to erosion is high. Extensive leveling is needed before this soil can be cultivated. The soil is used for range. (Capability unit VIIe–D, nonirrigated; Desert Loam Bottom range site)

**Ravola loam, extended season, 0 to 1 percent slopes** (RsA).—This soil is similar to Ravola loam, 1 to 3 percent slopes, except that it is nearly level. In addition, it is in an area in which the growing season is 140 to 160 days. It occupies flood plains of the Green River.

Included in mapping were small areas of Billings silty clay loam and Green River loam.

Runoff is slow, and the susceptibility to erosion is slight. The uniform distribution of water is needed. Many fields have been leveled, but leveling is still needed in some places to improve the distribution of water.

This soil is used for irrigated pasture, alfalfa, small grains, corn, melons, and sugar beets. The growing season is long enough for corn to mature and for alfalfa to produce three full cuttings in a year. (Capability unit I–1, irrigated; not rated for other uses)

**Ravola loam, extended season, 1 to 3 percent slopes** (RsB).—This soil is similar to Ravola loam, 1 to 3 percent slopes, except that it is in an area in which the growing season is 140 to 160 days. This soil is near Green River.

Included in mapping were some low spots in which the soil has a surface layer of silty clay loam, and some small areas of similar soils that are brown.

The growing season is long enough for corn to mature and for alfalfa to produce three full cuttings in a year. This soil is used for irrigated pasture, alfalfa, small grains, corn, melons, and sugar beets. (Capability unit IIe–1, irrigated; not rated for other uses)

**Ravola silty clay loam, 1 to 3 percent slopes** (RtB).—This soil has a surface layer of silty clay loam 8 to 15 inches thick, and it is gravelly in a few places. Otherwise, it is similar to Ravola loam, 1 to 3 percent slopes.

The infiltration rate is moderate to slow. This soil is fairly hard to work. A seedbed is more easily prepared if the soil is plowed in fall when barely moist, and is allowed to remain rough over winter, than if it is plowed in spring. This soil compacts if it is trampled or cultivated when wet.

This soil is used for irrigated pasture, alfalfa, small grains, and corn. (Capability units IIe–2, irrigated, and VIIs–D, nonirrigated; Desert Loam Bottom range site)

**Ravola-Bunderson complex, 1 to 3 percent slopes, eroded** (RuB2).—About 80 percent of this mapping unit is Ravola loam, 1 to 3 percent slopes, eroded, and 20 percent is Bunderson loam, 1 to 3 percent slopes, eroded. Typically, the Bunderson soil occupies slickspots that are inter-

spersed with areas of the Ravola soil (fig. 13). Both soils are on flood plains and alluvial fans.

Included in mapping were small areas of Billings silty clay loam.

Runoff is rapid from the Bunderson soil, and most areas contain gullies 5 to 20 feet deep and 500 to 1,300 feet apart. Head cutting is common, and it is forming shallow gullies. In places windblown hummocks less than 2 feet high occur. Typically, these are on the east and north sides of greasewood and other plants.

The soils in this mapping unit are suited to the production of range forage. Controlling gully erosion and regulating the amount and season of range use are needed. Clearing the brush and reseeding grasses are not feasible, because of the small amount of rainfall. (Both soils are in Capability unit VIIe–D, nonirrigated; Ravola soil is in Desert Loam Bottom range site)

**Riverwash** (Rv) consists of streambeds or riverbeds, including oxbow-loops and other channels. These areas are exposed at low water and subject to shifting during periods of high water because of deposition and erosion. The deposited materials are extremely variable, ranging from boulders in the upper part of streams to silt and clay in the lower, more nearly level areas. Most areas are channeled and have little or no cover of vegetation. (Capability unit VIIIw–4, nonirrigated; not rated for other uses)

**Rock land** (Ry) is a miscellaneous land type having a surface 50 to 70 percent covered by stones, boulders, and outcrops of shale and sandstone. Most of this land type is moderately eroded, but many areas are severely eroded. Soil characteristics are almost obscured by the stones and boulders. The slopes are very steep to perpendicular, but typically they are between 50 and 80 percent.

Included in mapping were gently sloping, deep fine sandy loams. Intermingled with the sandstone outcrops were inclusions of shallow fine sandy loams. Also included on some of the north-facing slopes in the mountains along the west side of the survey area were small areas of an unidentified soil.

*Figure 13.*—An area of Ravola-Bunderson complex, 1 to 3 percent slopes, eroded. The nearly bare, light-colored slickspots are the Bunderson soil.

This land type has almost no value for farming, although some areas have a sparse cover of grass, sagebrush, pinon, and juniper. This vegetation grows on all exposures, but it is dominant on north and west exposures. Small areas are accessible to livestock and wildlife, but most of the land type is too steep and rocky for grazing. (Capability unit VIIIs–3, nonirrigated; not rated for other uses)

## Saltair Series

Soils of the Saltair series are deep, poorly drained, very strongly saline, moderately fine textured, and nearly level to gently sloping. They occupy moderate to large areas on alluvial fans, on flood plains, and in narrow alluvial valleys. These soils have formed in alluvium derived from marine shale and sandstone. The vegetation is greasewood, saltgrass, and kochia, but bare surfaces are common. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous, very strongly saline silty clay loam about 7 inches thick. The underlying material is light brownish-gray and light-gray heavy silt loam that is very strongly saline in the upper part. Platy crusts of salt on the surface, underlain by layers of soft, granular material, are common. The content of salt is 2 percent or more within 20 inches of the surface.

This soil is used for range, but the quality of the forage is poor.

Representative profile of Saltair silty clay loam in a pasture, 1,200 feet north and 500 feet west of the SE. corner of section 13, T. 17 S., R. 9 E. in Emery County, Utah:

A11sa—0 to ½ inch, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, thin, platy structure breaking to moderate, fine, granular structure; soft, firm, very sticky and plastic; plentiful large roots; many medium and fine vesicular pores; strongly calcareous; strongly alkaline (pH 8.9); thin salt crust; clear, smooth boundary.

A12sa—½ inch to 7 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) when moist; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak to moderate, fine, angular blocky structure; very hard, very firm, very sticky and very plastic; plentiful medium and fine roots; common medium and fine pores; strongly calcareous; moderately alkaline (pH 8.3); very strongly saline; efflorescent salt on many ped surfaces and in pores; clear, smooth boundary.

C1gsa—7 to 14 inches, light brownish-gray (2.5Y 6/2) heavy silt loam, grayish brown (2.5Y 5/2) when moist; common, fine, distinct, yellowish-brown (10YR 5/4) mottles and common, fine, faint, gray (N 5/0) mottles; weak, fine, angular blocky structure; very hard, very firm, very sticky and very plastic; few fine roots; common medium pores; strongly calcareous; very strongly saline; efflorescent salt on many ped surfaces and in pores; strongly alkaline (8.5); gradual, wavy boundary.

C2gsa—14 to 32 inches, light brownish-gray (2.5Y 6/2) heavy silt loam, grayish brown (2.5Y 5/2) when moist; many, fine, distinct, yellowish-brown (10YR 5/4) mottles and common, fine, faint, gray (N 5/0) mottles; massive; very hard, firm, sticky and plastic; few fine roots; common medium and fine pores; strongly calcareous; very strongly saline; efflorescent salt on the surfaces of many peds and in pores; strongly alkaline (pH 8.5); gradual, wavy boundary.

C3g—32 to 60 inches, light-gray (2.5Y 7/2) heavy silt loam, grayish brown (2.5Y 5/2) when moist; few, fine, distinct, yellowish-brown (10YR 5/4) mottles and medium, faint, gray (N 5/0) mottles; massive; hard, firm, sticky and plastic; few fine roots; common fine pores; strongly calcareous; strongly alkaline (pH 8.5).

The content of salt is 2.0 percent or more in the upper 20 inches of the profile, and the rest of the profile also contains salt. The content of exchangeable sodium ranges from 15 to 70 percent. In the A1 horizons, the hue is 2.5Y or 5Y; value ranges from 4 to 6 when the soils are dry and from 5 to 7 when they are moist; and chroma is 1 or 2. The part of the profile between 10 and 40 inches is heavy silt loam, silty clay loam, or clay loam that contains less than 35 percent clay. All of the upper 40 inches is about the same color.

**Saltair silty clay loam** (0 to 3 percent slopes) (Sa).—The profile of this soil is the one described as typical of the series. The surface layer is ¼ to ½ inch thick, and it has platy structure but typically breaks to granules that contain numerous crystals of salt. A loose granular layer ½ inch to 3 inches thick, commonly lies below the salt crust. The content of salt typically is between 2 and 3 percent in the upper 20 inches of the profile. Included in mapping, however, were small areas of a soil in which the content of salt is between 1 and 2 percent. The water table occurs at depths of 6 to 60 inches but generally is at depths between 36 and 60 inches. Typically, mottles are less than 20 inches below the surface, but in places they are at a greater depth.

Drainage is poor, and permeability is slow. Roots generally are concentrated near the surface, but they penetrate to a depth of 5 feet. Runoff is slow, and the susceptibility to erosion is slight.

This soil is used for pasture, but the quality of the forage is poor. (Capability unit VIIw-28, nonirrigated; Salt Meadow range site)

**Saltair silty clay loam, barren** (0 to 3 percent slopes) (Sb).—This soil has a profile similar to the one described as typical for the series, except that the crust of salt on the surface is ½ to 1 inch thick. The content of salt is considerably more than 2 percent. The surface generally is bare, and only a few scattered greasewood plants survive. In some places dead stumps of greasewood are all that remain of plants that were killed by the high content of salt in this soil. (Capability unit VIIIw-8, nonirrigated; not rated for other uses)

## Sanpete Series

The Sanpete series consists of deep, well-drained, gently sloping, gravelly or cobbly soils that have formed in glacial outwash derived mainly from sandstone and quartzite. These soils occupy moderately large to large areas on mesas and benches along the west and south sides of the survey area. The vegetation is galletagrass, shadscale, black sage, and Indian ricegrass. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 7 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is pale-brown very fine sandy loam about 1 inch thick. The underlying material is light yelowish-brown to very pale brown, calcareous gravelly sandy clay loam and cobbly sandy clay loam to a depth of about 14 inches. Below this depth is very pale brown very cobbly sandy loam that contains a limy layer.

Sanpete soils are used mainly for range. Some areas are cultivated and are used for irrigated pasture, alfalfa, small grains, and corn. The soils are not well suited to these crops.

Representative profile of a Sanpete sandy clay loam, ,300 feet south and 1,000 feet west of the NE. corner of section 21, T. 18 S., R. 8 E., in Emery County, Utah:

A1—0 to 1 inch, pale-brown (10YR 6/3) very fine sandy loam, brown (10YR 5/3) when moist; weak, thin, platy structure breaking to weak, fine, granular structure; soft, friable, nonsticky and nonplastic; few fine roots; vesicular pores; moderately calcareous; mildly alkaline (pH 7.8); abrupt, smooth boundary.

C1—1 to 5 inches, light yellowish-brown (10YR 6/4) gravelly sandy clay loam, yellowish brown (10YR 5/4) when moist; weak, coarse, subangular blocky structure breaking to weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common medium-sized roots, and common fine, discontinuous pores; moderately calcareous; moderately alkaline (pH 8.0); clear, smooth boundary.

C2—5 to 9 inches, brownish-yellow (10YR 6/5) gravelly sandy clay loam, yellowish brown (10YR 5/5) when moist; moderate, coarse, angular blocky structure breaking to moderate, fine, angular and subangular blocky structure; slightly hard, friable, slightly sticky and plastic; plentiful medium and a few fine roots; few, fine, discontinuous pores; strongly calcareous, mildly alkaline (pH 7.8); clear, wavy boundary.

C3ca—9 to 14 inches, very pale brown (10YR 7/4) cobbly sandy clay loam, light yellowish brown (10YR 6/4) when moist; moderate, coarse, angular blocky structure breaking to fine angular and subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine roots; few, fine, discontinuous pores; very strongly calcareous; moderately alkaline (pH 8.1); gradual, wavy boundary.

C4ca—14 to 30 inches, very pale brown (10YR 8/3) very cobbly sandy loam, very pale brown (10YR 7/3) when moist; massive; slightly hard, friable, slightly sticky and slightly plastic; very strongly calcareous; moderately alkaline (pH 8.0); gradual, wavy boundary.

C5—30 inches +, very pale brown (10YR 7/3) very cobbly sandy loam, brown (10YR 5/3) when moist; massive; soft, very friable, nonsticky and nonplastic; no roots or pores; very strongly calcareous; strongly alkaline (pH 8.8).

Depth to the zone of lime accumulation ranges from 7 to 15 inches, and the accumulation is 8 to 24 inches thick. The soils generally are dry when not frozen, unless they are irrigated. In the A1 horizon, the hue is 7.5YR or 10YR; value ranges from 5.5 to 7 when the soils are dry and from 3.5 to 5 when they are moist; and chroma ranges from 2 to 5. The content of coarse fragments ranges from only a few percent to more than 50 percent, but 20 to 50 percent is typical. The part of the profile below 10 inches is sandy clay loam to sandy loam. The amount of coarse fragments in this part ranges from 20 to more than 70 percent, but on the basis of a weighted average the proportion is more than

50 percent. In the part of the profile below 10 inches, the hue ranges from 10YR to 5YR; value ranges from 6 to 8 when the soils are dry and from 4 to 7 when they are moist; and chroma ranges from 3 to 5.

Sanpete soils occur with the Minchey soils.

**Sanpete sandy clay loam, 1 to 3 percent slopes** (SIB).—The profile of this soil is the one described as representative of the series. Typically, gravel is in the upper 10 inches, and in places gravel is on the surface. Near the mountains on the upper parts of benches, the coarse fragments typically range from 3 to 20 inches in diameter. On the lower ends of the benches, 3 or 4 miles away from the mountains, the coarse fragments typically range from 1½ to 10 inches in diameter.

Drainage is good, and permeability is rapid. Root penetration is restricted by gravel and cobblestones below a depth of about 20 inches. About 3.5 inches of water is retained in this soil, but only about 2 inches of water is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is fairly hard to work. Leveling is difficult because of the cobblestones and gravel.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, and corn. Because of the short growing season, alfalfa produces only two full crops and part of a third in a year. Erosion is reduced if this soil is used for hay or pasture most of the time. Alfalfa responds well to applications of a phosphate fertilizer. (Capability units IVs–24, irrigated, and VIIs–S4, nonirrigated; Semi-Desert Limy Loam range site)

**Sanpete sandy clay loam, 3 to 10 percent slopes, eroded** (SID2).—The profile of this soil is similar to the one described as typical of the series, except that it has been eroded because of stronger slopes. Part or all of the surface layer has been lost through erosion. Lime-coated gravel and cobblestones on and near the surface indicate that soil has been removed from around them. In places the whitish, limy subsoil has been exposed as the result of erosion. This soil is on benches. Runoff is rapid, and the susceptibility to erosion is high. In places on the stronger slopes, shallow gullies have formed.

Included in mapping were areas of similar soils that are 20 to 36 inches deep over sandstone.

This soil is used mainly for spring and fall range. It is not well suited to cultivation, but irrigated alfalfa is grown, and some areas are used for irrigated pasture. (Capability units IVs–24, irrigated, and VIIs–S4, nonirrigated; Semi-Desert Limy Loam range site)

**Sanpete-Minchey complex, 1 to 10 percent slopes, eroded** (SmD2).—About 60 percent of this mapping unit is Sanpete sandy clay loam, 3 to 10 percent slopes, eroded, and 40 percent is Minchey loam, 1 to 3 percent slopes. These soils are so intermixed that they could not be separated in mapping. The Sanpete soil occupies ridges and the stronger slopes. It has lost part or all of its surface layer through erosion, and in places the whitish, limy subsoil is exposed. In addition, lime-coated gravel and cobblestones on or near the surface indicate that soil material has been removed from around them. In places shallow gullies have formed. The Minchey soil has gentle slopes and is less eroded than the Sanpete component of this mapping unit.

These soils are used mainly for spring and fall range. Where they are cultivated and irrigated, they are used for pasture and hay. (The Sanpete soil is in capability units VIIs–S4, nonirrigated, and IVs–24, irrigated; and in the Semi-Desert Limy Loam range site. The Minchey soil is in capability units VIIe–S4, nonirrigated, and IIe–24, irrigated; and in the Semi-Desert Limy Loam range site)

**Shaly colluvial land** (Sn) is a mixture of soil material, cobblestones, and fragments of rock. It has accumulated on moderately steep and steep slopes and at the bases of slopes, primarily as the result of gravity. This colluvium is variable in thickness, and in some places it is as much as 3 feet thick over shale. This miscellaneous land type is extensive in the survey area because the mesas or benches are capped with gravelly and cobbly glacial outwash. As the shale on the slopes of the mesas and benches erodes away, this capping falls and rolls down the slope. From 20 to 40 percent of the surface is shale outcrops. Because of the steep slopes, the lack of precipitation to establish plants, and the unconsolidated nature of the colluvium, moderate to severe erosion is active.

Included in mapping were some areas of medium-textured and moderately coarse textured soils that occupy the less steep slopes near the mountains. Included also were some areas of deep, gravelly heavy loams on narrow ridges.

The dominant vegetation is galletagrass and shadscale. Some of the gentler slopes have a good cover of galletagrass. This land type is used for spring and fall range. (Capability unit VIIs–DX, nonirrigated; Desert Cobbly Loam range site)

**Stony alluvial land** (St) consists of extremely stony alluvium from a variety of sedimentary rocks. It is mainly on the flood plains of live and ephemeral streams, but it also occurs on mud rock flows adjacent to the flood plains. The texture ranges from sandy loam to loam. Gravel, cobblestones, and other stones 3 inches to 4 feet in diameter make up 25 to 80 percent of the soil material (fig. 14). The content of stones and cobblestones varies significantly within a few feet.

The present vegetation is scattered juniper trees, galletagrass, rabbitbrush, and some big sagebrush. (Capability unit VIIs–SX, nonirrigated; Semi-Desert Stony Loam (Pinon-Juniper) range site)

## Woodrow Series

The Woodrow series consists of deep, moderately fine textured, well-drained, calcareous soils on alluvial fans, on flood plains, and in narrow alluvial valleys. These soils have formed in alluvium from mixed sedimentary rocks. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous, hard silty clay loam about 7 inches thick. The underlying material is light brownish-gray, very hard silty clay loam that contains thin layers of sandy loam or loam.

Most areas of this soil have been cleared and are used for irrigated pasture, alfalfa, small grains, corn, and sugar beets. The soils are well suited to these crops.

*Figure 14.*—An area of Stony alluvial land.

Representative profile of Woodrow silty clay loam in a cultivated area, 800 feet north and 750 feet east of the NE. corner of section 5, T. 18 S., R. 9 E., in Emery County, Utah:

Ap1—0 to 2 inches, light brownish-gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; soft, firm, slightly sticky and slightly plastic; plentiful large and medium roots; common, medium, continuous pores; strongly calcareous; mildly alkaline (pH 7.6); clear, smooth boundary.

Ap2—2 to 7 inches, light brownish-gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, subangular blocky structure breaking to moderate, medium and fine, granular structure; hard, firm, slightly sticky and plastic; plentiful roots of all sizes; common, medium, continuous pores; strongly calcareous; mildly alkaline (pH 7.6); clear, smooth boundary.

C1—7 to 19 inches, light brownish-gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) when moist; moderate, medium, angular blocky structure; very hard, very firm, sticky and plastic; plentiful medium and fine roots; common, medium, continuous pores and common, fine, discontinuous pores; strongly calcareous; mildly alkaline (pH 7.8); diffuse, wavy boundary.

C2—19 to 31 inches, light brownish-gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) when moist; weak, medium, subangular blocky structure; very hard, very firm, sticky and plastic; plentiful fine and few medium roots; common, fine, discontinuous pores; strongly calcareous; moderately alkaline (pH 7.9); diffuse, wavy boundary.

C3—31 to 60 inches, light brownish-gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) when moist; massive; very hard, very firm, sticky and plastic; few fine roots; common, fine, discontinuous pores; strongly calcareous; moderately alkaline (pH 7.9).

The soils are usually dry when not frozen, unless they are irrigated. Clay minerals are mixed, but dominantly they are montmorillonite. The content of lime ranges from 10 to 25 percent. In the A horizons, hue ranges from 10YR to 7.5YR; value ranges from 5 to 7 when the soils are dry and from 4 to 6 when they are moist; and chroma ranges from 2 to 4. The part of the profile between depths of 10 and 40 inches is clay loam to silty clay loam that contains 27 to 35 percent clay. All of the upper 40 inches is about the same color. Below a depth of 40 inches, the texture ranges from sandy loam to silty clay loam.

**Woodrow silty clay loam** (1 to 3 percent slopes) (Wo).—A profile of this soil is the one described as typical of the series. In places, however, the texture of the surface layer is loam. Below a depth of 40 inches the texture ranges from sandy loam to silty clay loam.

Included in the mapping were a few areas of soils that have slopes of less than 1 percent. Also included were small, strongly saline spots, less than one-half acre in extent, and areas of Penoyer loam and of Billings silty clay loam.

Drainage is good, but permeability is slow. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to a depth of 5 feet or more. This soil retains about 11 inches of water, but only about 5 inches of water is readily available to plants. The soil is fairly easy to work and to irrigate. The seedbed is more easily prepared if the soil is plowed in fall when barely moist, and is allowed to remain rough over winter, than when it is plowed in spring. Land leveling is needed in some areas so that water can be applied evenly over the soil.

This soil is used for irrigated pasture, alfalfa, small grains, corn, and sugar beets. The growing season is only long enough for alfalfa to produce two full crops and part of a third in a year. Corn does not mature for grain and is used for ensilage. A small acreage of this soil at Green River is nearly level. In this area the growing season is longer than in other places where the soil occurs, alfalfa produces three full crops a year, and corn matures for grain. Areas of this soil not in cultivation are used for spring and fall range. (Capability units IIe-2, irrigated, and VIIs-D, nonirrigated; Desert Loam Bottom range site)

## *Formation and Classification of Soils*

This section describes how the factors of soil formation have affected the development of soils in the Carbon-Emery Area. It also places the soil series represented in this survey area in some categories of the current system of soil classification.

### Formation of Soils

Soils are formed by the forces of the environment acting upon soil materials deposited or accumulated by various geologic agencies. The characteristics of a soil at any particular place on the earth depend upon (1) the chemical and mineralogical composition of the parent material; (2) the climate under which the parent material has existed since accumulation; (3) the length of time the parent material has been subjected to active weathering forces; (4) the relief or lay of the land; and (5) the plant and animal life on and in the soil, including man himself.

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Regional differences in soils usually reflect differences in climate and vegetation, but local differences are more often caused by differences in relief, parent material, and time. For example, all the soils of the Carbon-Emery Area are similar in some ways because they formed under similar climatic conditions and under essentially the same type of vegetation. None of the soils are strongly weathered, but the soils that have a well-developed profile are leached to a limited extent. Most of the soils are low in content of organic matter. Such features reflect the influences of climate and vegetation.

### Parent material

Parent material is an important factor in the formation of soils. In the Carbon-Emery Area, the parent material is of three main kinds—residuum that weathered from shale and sandstone; glacial outwash that was derived dominantly from sandstone and quartzite; and alluvium or colluvium that was derived mainly from shale or from glacial outwash. Facts about these three kinds of parent material are given in the following paragraphs. Additional information about the physical and chemical properties of the soils discussed can be found in tables 9 and 10 in the section "Laboratory Analyses."

*Residuum weathered from shale and sandstone.*—The Cedar Mountain, Chipeta, Persayo, and Killpack soils have developed in residiuum that weathered from shale, and they are typically salty. The parent material of the Cedar Mountain soils is reddish brown and hard. That of the other soils is brownish gray, soft, and silty, and it generally contains salts and gypsum.

A weak gypsum horizon immediately above the shale is typical in the shallow Chipeta and Persayo soils. Apparently, the weathering processes have broken down the shale faster than the small amount of rainfall has leached away the salts and gypsum.

Moderately deep Killpack soils are below the Chipeta soils, and they receive some local alluvium or colluvium. Because of their greater thickness, the Killpack soils absorb more precipitation than is absorbed by soils that have a thinner profile, though even less water reaches the layer of gypsum. As a result, the Killpack soils typically have a weak to moderate gypsum horizon immediately above the shale. Where these soils are irrigated, a noticeable decrease occurs in the amount of gypsum in the gypsum horizon.

The Castle Valley soils have developed in residuum that weathered from very fine grained sandstone and interbedded shale. These soils are shallow over sandstone and have an A1, a B2t, and a weak B2ca horizon. The A1 and B2t horizons are slightly calcareous. In many places the A1 horizon has been recharged by calcareous sediments, most likely deposited by wind.

*Glacial outwash derived dominantly from sandstone and quartzite.*—During Pleistocene time, glacial outwash of variable thickness was deposited along the northern and western edges of Castle Valley. Many small streams of melt water built local outwash fans, or aprons, beyond the ice front or at the ends of moraines. Outwash plains were formed by the merging of a series of these outwash fans, or aprons. There is no evidence of moraines on the outwash plains; consequently, it is doubtful that the ice fronts advanced that far. Since glacial time, erosion has dissected the outwash plains. Nearly level to gently sloping benches or mesas that have steep breaks, or escarpments, are typical features in these eroded areas. Erosion has isolated some areas, and left buttelike hills called mesas.

The deposit of glacial outwash ranges from 8 to 20 feet in thickness. Near the mountains the deposit is much thicker than elsewhere. In one location near the mountains, it is about 100 feet thick. At a distance of 3 to 4 miles from the mountains, however, the deposit is only a few inches thick or is entirely lacking. This outwash is highly variable in texture. It also contains a large amount of smooth, well-rounded gravel and cobblestones, indicating that this coarse material was transported a long distance by water. Indications are that sorting and grading have occurred. Near the mountains there are many stones as much as 3 feet in diameter. In contrast, the coarse fragments in the valley are mainly the sizes of cobblestones and pebbles. This is true because in the movement of outwash material the largest rocks are dropped first, and then the smaller materials.

Glacial outwash in the Carbon-Emery Area is composed of calcareous sandstone and quartzite. Under the outwash is Mancos shale.

*Alluvium.*—Soils that formed in alluvium occupy fans, flood plains, and alluvial plains. The alluvium has washed from shale rocks, and the soils that formed in it tend to be salty. The location of the Saltair, Libbings, and Cache soils makes them subject to flooding, and these soils also receive salty seepage water. When the seepage water evaporates, it leaves an accumulation of salt. The silty and clayey texture and slow permeability of the Saltair, Libbings, and Cache soils impede the leaching of the salt. As a result, these soils are very strongly saline. In contrast, the Ravola and Billings soils are only slightly to moderately saline.

The Penoyer soils have developed in alluvium derived from shale and glacial outwash, mixed with sediment deposited by streams that flow into the valley from mountains to the west. The parent material of the Penoyer soils contained more montmorillonitic clay than that of the other soils formed in alluvium. Consequently, the Penoyer soils have a high cation-exchange clay ratio.

The Minchey and Sanpete soils have developed in alluvium that was deposited by glacial streams. They have an accumulation of calcium carbonate at a depth below 7 to 20 inches. The intensity of this accumulation increases in the upper part of the C horizon. The calcium carbonate occurs as seams, veins, spots, or splotches, but mostly as a nearly white disseminated mass.

*Parent materials and soil salinity.*—Nature of parent materials has affected content of salts and alkali in the soils.

The parent rock of some soils consisted of calcareous sandstone. This is apparent because the sandstone that was collected from several areas contains from 16 to 40 percent calcium carbonate. As the sandstone weathered, calcium carbonate was continually added to these soils.

Some calcareous deposits were transported by wind. About 17 percent of the Carbon-Emery Area consists of bare shale or shale covered by a thin mantle of soil. From 12 to 20 percent of this shale is calcium carbonate. Winds blowing at a moderate to high velocity across this shale picked up calcareous sediment and deposited it

on vegetated areas. On one mesa the uppermost 3 inches of Minchey loam contains 1.2 percent more calcium carbonate than the underlying material. This mesa is isolated, so the additional calcium carbonate apparently was deposited by wind. In the Penoyer and Ravola soils, which have formed in alluvium, there is typically 2 to 10 percent more calcium carbonate above a depth of 20 inches than in the underlying material. In some places, however, the increase is slight, or is absent.

Precipitation and leaching have influenced the accumulation of calcium carbonate. The decomposition of calcareous rocks and the deposition of calcareous sediment on the surface provide a continuous supply of calcium carbonate. This mineral is translocated by leaching and is deposited when the moisture evaporates or is used by plants. The limited amount of rainfall in the Carbon-Emery Area seldom moistens the soil to a depth of more than 20 inches. As a result, the concentration of calcium carbonate in some soils makes up 35 to 70 percent of the soil material.

In such gravelly or cobbly soils as the Sanpete, encrustations of calcium carbonate are on the underside of coarse fragments in the Ca horizon. The relationship between soils and their position on the landscape, as influenced by parent materials, is shown in figure 15.

### Climate

The Carbon-Emery Area has a semiarid, continental type of climate. Humidity is low. Daily and seasonal temperatures vary over a wide range, and there is a large amount of sunshine. The growing season is 110 to 130 days, except that it is 140 to 160 days in an area near Green River. Because of the small amount of rainfall, a long period of time is required for climate to influence the formation of the soils. The effects of low rainfall are most strongly expressed in shallow soil profiles, light-colored A1 horizons, a low content of organic matter, and strongly developed Cca horizons.

Climatic records show that the average monthly precipitation is about 0.5 of an inch during the period of October through June and that it is about 1 inch in July, August, and September. The total yearly average precipitation is about 8 inches. During winter, when evaporation and transpiration are low, the precipitation that falls is largely available for storage if it enters the soil. During the period of November to March, the average precipitation is about 2.5 inches. Sanpete, Minchey, and Palisade soils, on the older land surfaces, have a strong Ca horizon at a depth of 7 to 20 inches. This is the depth to which winter precipitation moistens these soils.

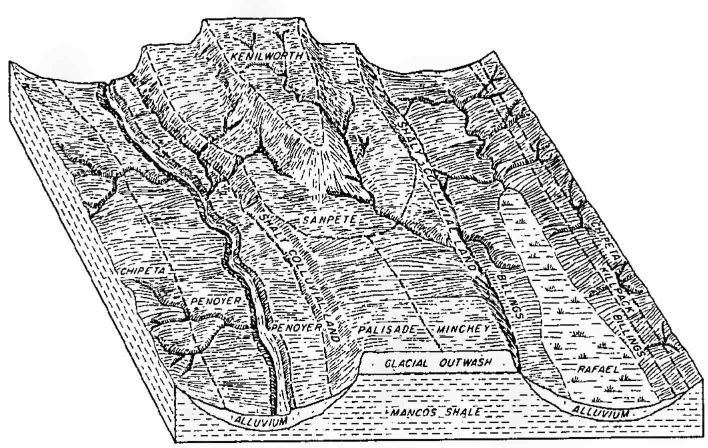


***Figure 15.*—Schematic cross section showing soils and underlying material north of Castle Dale.**

In March, April, and May, the Carbon-Emery Area frequently has winds of moderate to high velocity that dry the soils and increase the rates of evaporation and transpiration. These winds are important in the movement and redistribution of calcareous sediment because they occur before the soil warms up and protective vegetation has grown enough to help break the force of the wind. The widespread deposition of calcareous sediment by wind probably accounts for the calcareous A horizon in the Minchey, Sanpete, Palisade, and Castle Valley soils. The A1 horizon in the Castle Valley soils is also slightly more calcareous than the B horizon, and this indicates that calcareous sediment has been recently added to the surface.

### Time

In a semiarid climate the soil-forming processes are slow and require a much longer time to modify the parent material than is required in a wetter climate. The Castle Valley soils seem to be the oldest in the Area; that is, they have been subjected to horizon differentiation for the longest time. They have a moderately developed Bt horizon and contain accumulations of calcium carbonate.

The Minchey and Sanpete soils are intermediate in development. They show increased amounts of clay in the subsoil, but they lack clay films. They also have horizons that contain a strong accumulation of lime.

The least horizonation occurs in soils that have formed in alluvium—those of the Billings, Ravola, and Penoyer series. These soils are on alluvial fans and flood plains. The length of time the soil material has been in place is too short for genetic horizons to have formed in these soils, but some organic matter has accumulated in the surface layer to form a weakly developed A1 horizon. A buried A1 horizon is not uncommon.

The old dissected glacial outwash plains on which the Kenilworth soils occur appear to be old eroded land surfaces. The profile looks like the ca horizon of an eroded soil from which most of the solum has been removed. Kenilworth soils are developing in this ca horizon, which has been modified only by the translocation of lime and an increase in content of organic matter.

The following is evidence that an old soil may have existed on these dissected outwash plains. In places, the surface layer is sandy clay loam, and this might be a relict B horizon. Typically, the present surface layer contains slightly more clay than the substratum. In many places lime-coated gravel and cobblestones are on the surface. In a few places lime coatings on stones extend 2 to 6 inches above the surface. This evidence indicates that soil material has been removed from around the coarse surface material.

### Relief

Drainage, aeration, exposure, and susceptibility to erosion are factors of relief that affect the soil-forming proc-

esses. For example, the Kenilworth soils have a weakly developed A1 horizon that is slightly darker and more prominent on north and east exposures than on south and west exposures. Furthermore, similar vegetation is more vigorous on north and east exposures than on other exposures. These differences in vegetation probably are the result of less direct exposure to the sun on north- and east-facing slopes than on other slopes. In addition, soil temperature is lower, surface evaporation is less, and water for transpiration is less restricted on north- and east-facing slopes than on south- and west-facing slopes.

Most soils in the survey area apparently were well drained before they were irrigated. Since irrigation was started, a high water table has developed and salts have accumulated, resulting in the formation of the somewhat poorly drained and poorly drained saline soils of the Ferron, Hunting, and Saltair series. In many places this change in drainage can be attributed to differences in the surface of the underlying shale, which is undulating or uneven. Shale restricts the movement of underground water and causes this water to accumulate.

In some places, especially in depressions, the Saltair and Libbings soils have a crust of salt as much as 1½ inches thick on the surface. In those places salty water has seeped into the depressions and has left salt when it evaporated. These soils are bare or have only a sparse stand of pickleweed and greasewood.

### *Plant and animal life*

The natural vegetation in the Carbon-Emery Area consists of a sparse stand of desert shrubs and some bunch grasses. Along the streams are squawbush, cottonwood, and willow. Because plant growth is sparse, such soils as the Minchey, Sanpete, and Harding typically contain less than 1 percent organic matter under natural conditions. After a period of cultivation and irrigation, the organic matter in such soils as the Billings, Penoyer, and Ravola increases to 2 or 3 percent. This increase is the result of applications of some barnyard manure and of increases in the amount of plant residue returned to the soil through cultivation and irrigation. The content of organic matter does not increase above 2 or 3 percent. This level seems to represent the equilibrium in these climatic conditions for soils under irrigation.

Some areas that have a high water table support a growth of sedges and grasses. In such areas the content of organic matter in the O horizon of the Ferron, Rafael, and Abbott soils is 12 to 16 percent. Organic matter in the A1 horizon ranges from 3 to 6 percent, and it decreases with depth until there is only 1 to 2 percent at depths below 5 inches.

Greasewood and shadscale are two common salt-tolerant plants having fleshy leaves and thorns that exert considerable influence on the content of salt in the soils. This is especially true for the Beebe and Bunderson soils but to a less extent for the Ravola and Billings soils. The leaves of both greasewood and shadscale contain salts that have been assimilated from the soil, and they are salty to the taste. As the dropped leaves decompose, the mineral residue is again incorporated into the soil. Some of the salts are leached away, but sodium salts react with the soil to increase the amount of exchangeable sodium. Where sodium salts have accumulated, areas called slickspots appear. Slickspots are evident for many years after the greasewood plants have disappeared. A soil in these slickspots, designated "Beebe No. 1," in table 7, has pH paste values between 8.0 and 9.7. About 50 feet away, an irrigated, leached soil, designated "Beebe No. 2," has pH and exchangeable sodium values less than those of Beebe No. 1.

TABLE 7.—*A comparison of a Beebe soil before and after irrigation*

| Beebe No. 1, before irrigation | | | Beebe No. 2, after irrigation | | |
|---|---|---|---|---|---|
| Depth from surface | pH paste | Exchangeable sodium | Depth from surface | pH paste | Exchangeable sodium |
| *Inches* | | *Percent* | *Inches* | | *Percent* |
| 0–2 | 8.0 | 3 | 0–6 | 7.8 | 4 |
| 2–12 | 9.7 | 50 | 6–12 | 7.9 | 4 |
| 12–18 | 9.6 | 52 | 12–18 | 7.9 | 3 |
| 18–34 | 8.5 | 19 | 18–36 | 7.7 | 3 |
| 34–39 | 7.9 | 3 | 36–60 | 8.0 | 7 |
| 39–71 | 8.2 | 8 | | | |

Animals, as well as plants, have affected the formation of soils in the survey area. Prairie dogs, for example, have dug burrows that are especially noticeable in this semiarid area because of the sparse cover of vegetation. The prairie dog towns consist of a system of burrows and mounds. The subsoil becomes a mound when it is brought to the surface by prairie dogs when they dig their burrows. After a burrow is abandoned, the soil material on or near the surface fills the cavities and washes into the deeper soil horizons.

## Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodlands; in developing rural areas; in performing engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*6*) and later revised (*5*). The system currently used was adopted for general use by the National Cooperative Survey in 1965. The current system is under continual study. Therefore, readers interested in developments of the current system should search the latest literature available (*9*,*4*).

The current system of classification is based on morphological characteristics that reflect the genesis of soils. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In table 8 some of the classes in the current system are given for each soil series in the Carbon-Emery survey area.

## *Laboratory Analyses*

The results of laboratory analyses of samples, taken at the same location as the typical soil, are shown by horizons in tables 9 and 10. The analyses in table 9 were made by the Soil Conservation Service and Utah State University Cooperative Soils Laboratory, Logan, Utah. Those in table 10 were made by the Agricultural Research Service.

### Methods of Analyses

All samples were air dried in the laboratory. They were then sieved through round openings 2 millimeters in diameter. Samples that appeared to contain no appreciable amount of pebbles or stones, that is, less than 5 percent, were poured through a mechanical crusher that has openings about 4 millimeters in diameter. Samples that contained an appreciable amount of pebbles or stones were broken up in an iron mortar without crushing the pebbles or stones. Where it was necessary to reduce the size of the sample, a Riffle sampler was used. Each laboratory sample was mixed thoroughly to insure uniformity, and all subsequent analyses were made on the fraction that was less than 2 millimeters in diameter. The percentage of material greater than 2 millimeters in diameter was calculated by dividing the weight of the fraction retained on the 2-millimeter sieve by the initial weight of the air-dry sample. Subsamples less than 2 millimeters in diameter were ground small enough to pass a sieve of 0.3 millimeter by use of a mortar and pestle. These subsamples were used to determine organic carbon and the calcium carbonate equivalent.

The reaction, or pH, was measured with a line-operated pH meter using a glass electrode with a calomel reference electrode. In determining the pH of soil-water suspensions in a ratio of one to five, the suspensions were stirred vigorously immediately before the electrodes were inserted. At the first indication of stabilization, the pH was read; then, the process was repeated until duplicate readings were obtained. Distilled water, or water free of carbon dioxide, was used for all soil-water suspensions.

In determining the content of soluble salts, a standard Bureau of Soils cup was used to obtain the ohms of resistance of the soil paste at saturation moisture content. The percentage of total soluble salts was then obtained from standard tables after correcting for soil texture and temperature.

#### *Gypsum*

The amount of calcium plus magnesium found in 1:10, 1:20, 1:50 or 1:100 water extract, less than found in saturation extract, was considered to be derived from gypsum. Calcium plus magnesium in both cases was determined by titration with versenate, using Eriochrome Black T as an indicator. Exchangeable sodium percentage (ESP) value was obtained by dividing the amount of exchangeable sodium by the cation-exchange capacity and multiplying the results by 100.

TABLE 8.—*Classification of soil series*

| Series | Family | Subgroup | Order |
|---|---|---|---|
| Abbott | Fine, montmorillonitic, calcareous, mesic | Fluventic Haplaquepts | Inceptisols. |
| Beebe | Sandy, mixed, mesic | Typic Torrifluvents | Entisols. |
| Billings | Fine-silty, mixed, calcareous, mesic | Typic Torrifluvents | Entisols. |
| Bunderson | Fine-silty, mixed, calcareous, mesic | Typic Torrifluvents | Entisols. |
| Cache | Fine, mixed, mesic | Typic Salorthids | Aridisols. |
| Castle Valley | Loamy, mixed, mesic | Lithic Xerollic Haplargids | Aridisols. |
| Cedar Mountain | Loamy, mixed, mesic | Lithic Camborthids | Aridisols. |
| Chipeta | Clayey, mixed, calcareous, mesic, shallow | Typic Torriorthents | Entisols. |
| Ferron | Coarse-silty, mixed, calcareous, mesic | Fluventic Haplaquepts | Inceptisols. |
| Green River | Coarse-loamy, mixed, calcareous, mesic | Aquic Ustifluvents | Entisols. |
| Harding | Fine, mixed, mesic | Typic Natrargids | Aridisols. |
| Hunting | Fine-silty, mixed, calcareous, mesic | Aquic Ustifluvents | Entisols. |
| Kenilworth | Loamy-skeletal, mixed, mesic | Xerollic Calciorthids | Aridisols. |
| Killpack | Fine-silty, mixed, calcareous, mesic | Typic Torriorthents | Entisols. |
| Libbings | Fine, mixed, mesic | Ustollic Salorthids | Aridisols. |
| Minchey | Fine-loamy, mixed, mesic | Typic Calciorthids | Aridisols. |
| Palisade | Coarse-loamy, mixed, mesic | Xerollic Calciorthids | Aridisols. |
| Persayo | Loamy, mixed, calcareous, mesic, shallow | Typic Torriorthents | Entisols. |
| Penoyer | Coarse-silty, mixed, calcareous, mesic | Typic Torrifluvents | Entisols. |
| Rafael | Fine-silty, mixed, calcareous, mesic | Typic Haplaquepts | Inceptisols. |
| Ravola | Fine-silty, mixed, calcareous, mesic | Typic Torrifluvents | Entisols. |
| Saltair | Fine-silty, mixed, mesic | Typic Salorthids | Aridisols. |
| Sanpete | Loamy-skeletal, mixed, mesic | Xerollic Calciorthids | Aridisols. |
| Woodrow | Fine-silty, mixed, calcareous, mesic | Typic Torrifluvents | Entisols. |

TABLE 9.—*Physical and chemical*

[Absence of data indicates that

| Soil | Depth | Size class and diameter of particles | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Very coarse sand (2–1 mm.) | Coarse sand (1–0.5 mm.) | Medium sand (0.5–0.25 mm.) | Fine sand (0.25–0.1 mm.) | Very fine sand (0.1–0.05 mm.) | Silt (0.05–0.002 mm.) | Clay (<0.002 mm.) |
| | *In.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* |
| Abbott silty clay. | 1½–0 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 0–6 | ---- | 0 | 0 | 0. 6 | 1. 2 | 37. 3 | 60. 9 |
| | 6–14 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 14–21 | ---- | . 1 | . 1 | . 8 | 5. 5 | 50. 7 | 42. 8 |
| | 21–29 | ---- | . 1 | 0 | . 2 | 2. 2 | 45. 4 | 52. 1 |
| | 29–36 | ---- | . 1 | . 1 | . 6 | 7. 5 | 52. 2 | 39. 5 |
| | 36–45 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 45–60 | ---- | . 1 | . 2 | 2. 2 | 18. 7 | 53. 7 | 25. 1 |
| Beebe loamy fine sand. | 0–2 | . 1 | . 5 | 1. 3 | 10. 2 | 44. 3 | 35. 0 | 8. 6 |
| | 2–12 | 0 | . 5 | 3. 5 | 32. 9 | 44. 7 | 12. 3 | 6. 1 |
| | 12–16 | 1. 1 | 10. 0 | 25. 2 | 37. 9 | 16. 0 | 6. 1 | 3. 7 |
| | 16–34 | . 1 | . 7 | 2. 9 | 35. 1 | 41. 5 | 13. 9 | 5. 8 |
| | 34–39 | . 1 | . 8 | 4. 2 | 17. 3 | 24. 6 | 34. 8 | 18. 2 |
| | 39–71 | . 1 | 1. 3 | 6. 9 | 43. 4 | 29. 1 | 12. 6 | 6. 5 |
| Billings silty clay loam. | 0–3 | ---- | ---- | ---- | ---- | ---- | 46. 0 | 29. 0 |
| | 3–11 | ---- | ---- | ---- | ---- | ---- | 50. 0 | 33. 0 |
| | 11–18 | ---- | ---- | ---- | ---- | ---- | 52. 0 | 34. 0 |
| | 18–42 | ---- | ---- | ---- | ---- | ---- | 51. 0 | 38. 0 |
| | 42–58 | ---- | ---- | ---- | ---- | ---- | 52. 0 | 38. 0 |
| Bunderson loam. | 0–1 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 1–4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 4–11 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 11–18 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 18–31 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 31–38 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| | 38–72 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Castle Valley very fine sandy loam. | 0–2 | 0 | . 2 | . 7 | 15. 8 | 63. 8 | 13. 5 | 6. 0 |
| | 2–5 | 0 | . 3 | 1. 0 | 13. 2 | 56. 0 | 14. 6 | 14. 9 |
| | 5–10 | . 1 | . 3 | . 9 | 12. 8 | 50. 8 | 19. 8 | 15. 3 |
| Cedar Mountain shaly clay loam. | 0–3 | . 2 | . 4 | . 6 | 5. 5 | 18. 3 | 38. 4 | 36. 6 |
| | 3–7 | . 5 | . 6 | . 6 | 3. 4 | 9. 3 | 45. 0 | 40. 6 |
| | 7–14 | . 8 | 1. 1 | 1. 1 | 3. 0 | 7. 5 | 61. 5 | 25. 0 |
| Chipeta silty clay loam. | 0–5 | . 3 | . 4 | . 5 | 5. 3 | 5. 9 | 53. 6 | 34. 0 |
| | 5–13 | [2] | 0 | . 2 | 1. 5 | 6. 6 | 52. 6 | 39. 1 |
| | 13–17 | [2] | [2] | . 1 | . 5 | 2. 1 | 57. 3 | 40. 0 |
| Hunting loam. | 0–9 | . 1 | . 2 | . 7 | 7. 7 | 33. 7 | 34. 2 | 23. 4 |
| | 9–27 | 0 | . 1 | . 5 | 5. 5 | 28. 3 | 43. 9 | 21. 7 |
| | 27–30 | 0 | . 1 | . 9 | 7. 5 | 30. 8 | 33. 4 | 27. 3 |
| | 30–48 | 0 | 0 | . 3 | 3. 3 | 36. 0 | 41. 9 | 18. 5 |
| | 48–60 | . 1 | . 3 | 1. 2 | 6. 8 | 41. 0 | 34. 6 | 16. 0 |
| Kenilworth very stony sandy loam. | 0–7 | . 5 | 3. 9 | 12. 6 | 28. 3 | 17. 9 | 21. 8 | 15. 0 |
| | 7–13 | 1. 3 | 4. 4 | 11. 4 | 24. 9 | 17. 6 | 25. 1 | 15. 3 |
| | 13–21 | 1. 2 | 4. 6 | 12. 0 | 27. 8 | 18. 9 | 24. 5 | 11. 0 |
| | 21–34 | 2. 8 | 5. 5 | 10. 1 | 25. 1 | 18. 7 | 26. 3 | 11. 5 |
| Killpack clay loam. | 0–9 | . 2 | . 6 | 1. 1 | 3. 6 | 25. 0 | 42. 1 | 27. 4 |
| | 9–23 | . 2 | . 4 | . 6 | 2. 1 | 28. 7 | 40. 4 | 27. 6 |
| | 23–29 | . 1 | . 3 | . 2 | 1. 0 | 17. 5 | 48. 3 | 32. 6 |
| Libbings silty clay loam. | 0–½ | . 5 | . 6 | . 4 | 2. 9 | 18. 2 | 49. 7 | 27. 7 |
| | ½–2 | . 2 | . 4 | . 4 | 2. 1 | 13. 6 | 53. 8 | 29. 5 |
| | 2–9 | . 1 | . 1 | . 2 | 1. 6 | 9. 6 | 49. 9 | 38. 5 |
| | 9–25 | . 5 | 15. 3 | . 7 | 1. 7 | 5. 3 | 33. 6 | 42. 9 |
| | 25–34 | . 1 | . 8 | 1. 1 | 3. 2 | 2. 7 | 52. 1 | 40. 0 |

See footnotes at end of table.

*properties of selected soils*

values were not determined]

| Other classes: Sand | Other classes: Less than 2 mm. | pH paste | Exchangeable sodium | Calcium carbonate equivalent | Gypsum | Estimated salts (Bureau cup) | Organic matter |
|---|---|---|---|---|---|---|---|
| *Pct.* | *Pct.* | | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* |
| ---- | ---- | 7.1 | ---- | 37.2 | 0.1 | 0.48 | 12.20 |
| ---- | ---- | 7.1 | 8 | 27.6 | .2 | .57 | 5.90 |
| ---- | ---- | 7.3 | ---- | 20.8 | 3.9 | .52 | 3.29 |
| ---- | ---- | 7.6 | 17 | 16.8 | 2.4 | .40 | 2.75 |
| ---- | ---- | 7.6 | ---- | 18.5 | 1.6 | .35 | 2.30 |
| ---- | ---- | 7.7 | ---- | 17.2 | ---- | .23 | 2.46 |
| ---- | ---- | 7.9 | ---- | 21.0 | ---- | .19 | ---- |
| ---- | ---- | 7.9 | ---- | 30.2 | ---- | .16 | 1.20 |
| | | | | | | | |
| ---- | ---- | 8.0 | 3 | ---- | <1 | .10 | 2.25 |
| ---- | ---- | 9.7 | 50 | ---- | <1 | .10 | .38 |
| ---- | ---- | 9.6 | 52 | ---- | <1 | .08 | .14 |
| ---- | ---- | 8.5 | 19 | ---- | <1 | .12 | .83 |
| ---- | ---- | 7.9 | 3 | ---- | <1 | .10 | .83 |
| ---- | ---- | 8.2 | 8 | ---- | <1 | .03 | .24 |
| | | | | | | | |
| 25 | ---- | 7.9 | 2 | 19.2 | <1 | .15 | 2.92 |
| 17 | ---- | 8.0 | 3 | 19.1 | <1 | .08 | 2.22 |
| 14 | ---- | 7.8 | 4 | 20.1 | .1 | .17 | 1.08 |
| 11 | ---- | 7.6 | 5 | 17.2 | 6.9 | .24 | .81 |
| 10 | ---- | 8.0 | 10 | 17.5 | 6.9 | .37 | .81 |
| | | | | | | | |
| ---- | ---- | 9.3 | 79 | ---- | ---- | .33 | .21 |
| ---- | ---- | 10.0 | 96 | ---- | ---- | .61 | .34 |
| ---- | ---- | 8.7 | 61 | ---- | ---- | .70 | .59 |
| ---- | ---- | 8.4 | 31 | ---- | .02 | .55 | .60 |
| ---- | ---- | 8.0 | 11 | ---- | ---- | .36 | .41 |
| ---- | ---- | 7.9 | 15 | ---- | 1.2 | .40 | .41 |
| ---- | ---- | 7.9 | 15 | ---- | 1.1 | .34 | .51 |
| | | | | | | | |
| ---- | ---- | 7.6 | 4 | 2.3 | ---- | .03 | .77 |
| ---- | ---- | 7.5 | 3 | .2 | ---- | .03 | .89 |
| ---- | ---- | 7.6 | 2 | 10.7 | ---- | .04 | [1] 2.04 |
| | | | | | | | |
| ---- | ---- | 8.0 | 11 | 14.4 | ---- | .08 | .26 |
| ---- | ---- | 8.2 | 22 | 21.4 | ---- | .10 | .26 |
| ---- | ---- | 8.2 | 35 | 25.1 | ---- | .15 | .17 |
| | | | | | | | |
| ---- | ---- | 7.7 | 3 | 18.7 | ---- | .22 | 2.37 |
| ---- | 0 | 7.6 | 3 | 14.5 | ---- | .32 | 1.36 |
| ---- | 0 | 7.4 | 5 | 14.2 | 10.2 | .29 | 1.27 |
| | | | | | | | |
| ---- | ---- | 8.0 | ---- | 16.1 | ---- | .06 | 2.02 |
| ---- | ---- | 8.0 | 3 | 16.7 | ---- | <.09 | .91 |
| ---- | ---- | 7.9 | 3 | 13.2 | 3.5 | <.20 | .64 |
| ---- | ---- | 8.2 | 12 | 14.2 | 3.7 | .36 | ---- |
| ---- | ---- | 8.2 | 13 | 14.3 | 3.5 | .34 | ---- |
| | | | | | | | |
| ---- | ---- | 7.7 | 4 | 37.6 | ---- | .02 | 2.60 |
| ---- | ---- | 8.0 | 4 | 40.1 | ---- | .02 | 1.55 |
| ---- | ---- | 8.2 | 6 | 34.1 | ---- | .02 | 1.22 |
| ---- | ---- | 8.5 | 7 | 32.6 | ---- | .02 | .64 |
| | | | | | | | |
| ---- | ---- | 7.8 | 3 | 17.0 | ---- | .08 | 2.15 |
| ---- | ---- | 7.7 | 3 | 18.6 | .6 | .17 | 1.31 |
| ---- | ---- | 7.7 | 3 | 17.7 | 8.8 | .20 | .69 |
| | | | | | | | |
| ---- | ---- | 8.5 | 6 | 13.6 | ---- | 2.0 | 1.39 |
| ---- | ---- | 8.9 | 13 | 12.1 | ---- | 2.0 | 1.60 |
| ---- | ---- | 8.6 | 65 | 15.4 | ---- | 2.0 | 1.20 |
| ---- | ---- | 8.6 | 55 | 18.4 | 6.6 | 2.0 | 1.63 |
| ---- | ---- | 8.7 | 50 | 16.5 | 7.1 | 1.2 | 1.24 |

TABLE 9.—*Physical and chemical*

| Soil | Depth | Size class and diameter of particles | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Very coarse sand (2–1 mm.) | Coarse sand (1–0.5 mm.) | Medium sand (0.5–0.25 mm.) | Fine sand (0.25–0.1 mm.) | Very fine sand (0.1–0.05 mm.) | Silt (0.05–0.002 mm.) | Clay (<0.002 mm.) |
| | *In.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* |
| Minchey loam. | 0–3 | . 5 | 1. 5 | 4. 3 | 11. 0 | 26. 6 | 35. 4 | 20. 8 |
| | 3–12 | 0 | . 6 | 2. 2 | 6. 1 | 16. 8 | 36. 9 | 37. 4 |
| | 12–20 | 1. 4 | 1. 6 | 3. 5 | 8. 4 | 19. 1 | 29. 6 | 36. 4 |
| | 20–32 | 3. 7 | 6. 8 | 9. 9 | 16. 2 | 12. 6 | 20. 4 | 30. 4 |
| | 32–48 | . 4 | 1. 4 | 7. 5 | 28. 0 | 32. 5 | 17. 6 | 12. 6 |
| Palisade very fine sandy loam. | 0–3 | . 3 | 2. 2 | 8. 9 | 36. 4 | 31. 0 | 12. 9 | 8. 3 |
| | 3–8 | . 1 | 1. 0 | 5. 6 | 25. 2 | 30. 8 | 17. 9 | 19. 4 |
| | 8–18 | . 2 | 1. 3 | 5. 1 | 19. 5 | 27. 1 | 26. 9 | 19. 9 |
| | 18–29 | . 6 | 2. 0 | 5. 1 | 21. 4 | 26. 6 | 28. 1 | 16. 2 |
| | 29–41 | . 5 | 1. 4 | 5. 6 | 24. 0 | 27. 7 | 28. 3 | 12. 5 |
| | 41–60 | . 4 | 1. 1 | 4. 7 | 20. 3 | 30. 5 | 30. 2 | 12. 5 |
| Penoyer loam. | 0–4 | . 2 | . 6 | 1. 4 | 8. 9 | 32. 3 | 40. 2 | 16. 4 |
| | 4–9 | . 1 | . 5 | 1. 0 | 8. 6 | 27. 6 | 44. 8 | 17. 4 |
| | 9–23 | 0 | . 8 | 1. 1 | 14. 6 | 41. 8 | 28. 7 | 13. 0 |
| | 23–41 | 0 | . 5 | . 7 | 6. 7 | 43. 4 | 33. 8 | 14. 9 |
| | 41–60 | . 1 | . 7 | 1. 3 | 9. 1 | 38. 6 | 36. 1 | 14. 1 |
| Persayo loam. | 0–1 | 0 | . 1 | . 4 | 2. 7 | 43. 2 | 37. 0 | 16. 6 |
| | 1–3 | . 1 | . 2 | . 3 | 2. 1 | 35. 7 | 42. 9 | 18. 7 |
| | 3–8 | 0 | . 1 | . 2 | 1. 2 | 27. 8 | 44. 6 | 26. 1 |
| | 8–12 | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- | ---------- |
| Rafael silty clay loam. | 0–3 | . 3 | 1. 2 | 3. 3 | 9. 5 | 27. 0 | 33. 5 | 25. 2 |
| | 3–11 | . 1 | . 5 | 1. 3 | 5. 5 | 27. 3 | 42. 4 | 22. 9 |
| | 11–17 | . 1 | . 5 | 1. 7 | 6. 8 | 30. 2 | 38. 0 | 22. 7 |
| | 17–33 | 0 | . 1 | . 4 | 2. 3 | 14. 0 | 45. 3 | 37. 9 |
| | 33–43 | . 1 | . 6 | 1. 9 | 6. 4 | 28. 9 | 38. 9 | 23. 2 |
| | 43–70 | . 1 | . 3 | 1. 4 | 5. 7 | 24. 8 | 41. 2 | 26. 5 |
| Ravola silty clay loam. | 0–6 | ---------- | ---------- | ---------- | ---------- | ---------- | 47. 0 | 26. 0 |
| | 6–9 | ---------- | ---------- | ---------- | ---------- | ---------- | 48. 0 | 27. 0 |
| | 9–18 | ---------- | ---------- | ---------- | ---------- | ---------- | 45. 0 | 23. 0 |
| | 18–45 | ---------- | ---------- | ---------- | ---------- | ---------- | 48. 0 | 18. 0 |
| | 45–60 | ---------- | ---------- | ---------- | ---------- | ---------- | 36. 0 | 14. 0 |
| Saltair silty clay loam. | 0–½ | . 1 | . 1 | . 1 | . 3 | 2. 2 | 49. 3 | 47. 9 |
| | ½–7 | . 1 | . 1 | . 1 | . 4 | 6. 7 | 52. 2 | 40. 4 |
| | 7–14 | 0 | 0 | . 1 | . 8 | 17. 9 | 55. 5 | 25. 6 |
| | 14–32 | 0 | 0 | . 1 | . 5 | 18. 1 | 56. 1 | 25. 2 |
| | 32–60 | 0 | 0 | 0 | . 7 | 13. 2 | 60. 7 | 25. 4 |
| Sanpete sandy clay loam. | 0–1 | 1. 9 | 2. 8 | 4. 6 | 18. 3 | 48. 7 | 17. 8 | 5. 9 |
| | 1–5 | 1. 2 | 2. 0 | 3. 2 | 13. 4 | 32. 0 | 25. 1 | 23. 1 |
| | 5–9 | . 5 | 2. 1 | 3. 8 | 12. 1 | 26. 1 | 26. 0 | 26. 0 |
| | 9–14 | . 9 | 5. 0 | 7. 6 | 15. 1 | 19. 3 | 26. 8 | 25. 3 |
| | 14–30 | 1. 9 | 8. 5 | 10. 9 | 19. 8 | 18. 4 | 22. 4 | 18. 1 |
| Woodrow silty clay loam. | 0–2 | . 4 | . 3 | . 3 | 3. 0 | 4. 9 | 59. 2 | 31. 9 |
| | 2–7 | . 1 | . 3 | . 5 | 2. 6 | 5. 1 | 60. 0 | 31. 4 |
| | 7–19 | 0 | 0 | . 1 | . 6 | 1. 9 | 64. 2 | 33. 2 |
| | 19–31 | . 1 | . 1 | . 2 | . 7 | 1. 3 | 66. 1 | 31. 5 |
| | 31–60 | 0 | 0 | . 1 | . 3 | . 7 | 69. 4 | 29. 5 |

[1] Value is high because roots were matted above the horizon.
[2] Trace.

*properties of selected soils*—Continued

| Other classes | | pH paste | Exchangeable sodium | Calcium carbonate equivalent | Gypsum | Estimated salts (Bureau cup) | Organic matter |
|---|---|---|---|---|---|---|---|
| Sand | Less than 2 mm. | | | | | | |
| *Pct.* | *Pct.* | | *Pct.* | *Pct.* | *Pct.* | *Pct.* | *Pct.* |
| | | 8.2 | 16 | 5.4 | | .04 | .79 |
| | | 8.0 | 5 | 4.2 | | .05 | .77 |
| | | 8.3 | 5 | 14.3 | | .05 | .84 |
| | | 8.2 | 5 | 44.0 | | .10 | .95 |
| | | 7.9 | 6 | 15.3 | | .17 | .58 |
| | | | | | | | |
| | | 8.2 | 5 | 8.5 | | .03 | 1.14 |
| | | 8.1 | 3 | 11.8 | | .03 | .55 |
| | | 8.0 | 3 | 22.2 | | .03 | .34 |
| | | 8.3 | 5 | 24.5 | | .03 | .28 |
| | | 8.6 | 5 | 23.9 | | .03 | .19 |
| | | 8.5 | 14 | 17.3 | | .15 | .33 |
| | | | | | | | |
| | | 7.7 | | 23.5 | | .04 | 1.72 |
| | | 7.7 | | 23.2 | | .04 | 2.08 |
| | | 7.9 | | 16.2 | | .03 | 1.03 |
| | | 8.0 | 5 | 13.0 | <1 | .03 | .31 |
| | | 8.2 | 11 | 15.2 | <1 | .03 | |
| | | | | | | | |
| | 5 | 7.7 | 1 | 16.2 | | .05 | .60 |
| | 5 | 7.7 | 1 | 15.5 | | .06 | .60 |
| | 6 | 7.5 | 1 | 17.5 | 8.3 | .15 | .89 |
| | | | | | | | |
| | | | | | | | |
| | | 8.0 | 6 | 16.3 | 2.2 | .31 | 4.76 |
| | | 8.4 | 22 | 14.7 | .9 | .59 | .72 |
| | | 8.6 | 31 | 15.2 | .8 | .69 | .71 |
| | | 8.6 | 21 | 14.8 | 1.2 | 1.02 | 1.00 |
| | | 8.3 | 18 | 14.7 | 1.0 | .51 | |
| | | 8.2 | 14 | 15.2 | .9 | .39 | |
| | | | | | | | |
| 27 | | 7.8 | 2 | 12.7 | <1 | .06 | 2.73 |
| 25 | | 7.7 | 2 | 12.1 | <1 | .05 | 1.65 |
| 32 | | 7.7 | 3 | 11.9 | <1 | .05 | .96 |
| 34 | | 7.9 | 3 | 12.7 | <1 | .04 | .67 |
| 50 | | 7.9 | 5 | 12.6 | <1 | .03 | .52 |
| | | | | | | | |
| | | 8.9 | 100 | 19.1 | 4.8 | 2.35 | 2.65 |
| | | 8.3 | 70 | 18.8 | .4 | 2.16 | 1.27 |
| | | 8.5 | 87 | 15.4 | .7 | 1.99 | .86 |
| | | 8.5 | 74 | 16.7 | .7 | 1.77 | .96 |
| | | 8.5 | 80 | 17.7 | 1.0 | 1.66 | |
| | | | | | | | |
| | | 7.8 | | 10.7 | | .03 | 1.01 |
| | | 8.0 | | 13.5 | | .04 | .83 |
| | | 7.8 | | 27.5 | | .04 | 1.31 |
| | | 8.1 | | 45.0 | | .03 | 1.07 |
| | 34 | 8.0 | | 74.7 | | .04 | 1.31 |
| | | | | | | | |
| | | 7.6 | | 18.3 | | .07 | 3.13 |
| | | 7.6 | | 18.1 | | .07 | 2.61 |
| | | 7.8 | | 20.7 | | .07 | .79 |
| | | 7.9 | | 19.9 | | .08 | .71 |
| | | 7.9 | | 20.5 | | .10 | |

335-819—70——6

TABLE 10.—*Analysis of clay in selected soils*

[Absence of data indicates values were not determined]

| Soil series and horizons | Depth | Cation-exchange capacity/clay ratio | Clay minerals [1] |
|---|---|---|---|
| | *Inches* | | |
| Billings: | | | |
| Ap1 | 0–3 | 0.6 | IK/M |
| Ap2 | 3–11 | .5 | IK/M |
| C1 | 11–18 | .4 | IK/M |
| C2 | 18–42 | .4 | IKM |
| C3 | 42–58 | .4 | IKM |
| Minchey: | | | |
| A1 | 0–3 | | IK |
| C1 | 3–12 | | IK |
| C2ca | 12–20 | | IK |
| C3ca | 20–32 | | IKM |
| C4ca | 32–48 | | IKM |
| Penoyer: | | | |
| Ap1 | 0–4 | .7 | IKM |
| Ap2 | 4–9 | .7 | IKM |
| C1 | 9–23 | .6 | IKM |
| C2 | 23–41 | .5 | IKM/V |
| C3 | 41–60 | .5 | IKMV |
| Ravola: | | | |
| Ap1 | 0–6 | .4 | IK/MV |
| Ap2 | 6–9 | .4 | IK/MV |
| C1 | 9–18 | .4 | IK/MV |
| C2 | 18–45 | .4 | IK/MV |
| C3 | 45–60 | .4 | IK/MV |
| Sanpete: | | | |
| A1 | 0–1 | | IK/M |
| C1 | 1–5 | | IKM |
| C2 | 5–9 | | IKM |
| C3ca | 9–14 | | M/IK |
| C4ca | 14–30 | | M/IK |
| C5 | 30+ | | M/IK |

[1] Letter symbols have the following meaning: I, illite; K, kaolinite; M, montmorillonite; V, vermiculite. If a symbol is on the right side of the virgule (/), this mineral is present in minor quantity.

All percentage values and milliequivalents per 100 grams are on the basis of ovendry soil.

Organic matter was destroyed by using hydrogen peroxide, but lime was not removed, except where specifically stated in the survey. Sodium hexametaphosphate was used as a dispersing agent. The sand fractions were determined by mechanical sieving through a series of sieves 2 inches in diameter. Except for glassware, all equipment used in making the analyses was furnished by the Soil Survey Laboratory at Beltsville, Md. The pipette method of analysis was used to determine the amount of clay.

The wet oxidation method using chromic acid was used to determine the organic carbon. Samples were heated during the oxidation process as described in the U.S. Department of Agriculture Handbook No. 60 (*8*). Silver sulfate was added to the sulfuric acid to prevent oxidation of chlorides for samples where soluble salts were 0.1 percent or more. After oxidation and dilution, an excess of ferrous ammonium sulfate was added to the sample, and the sample was then titrated with standard potassium permanganate. The permanganate also acted as an indicator, and a special titration light was used to help determine the exact endpoint.

Determination of calcium carbonate equivalent was made by allowing variable weights of the sample to react in constant glass containers with 2 N hydrochloric acid. The percentage of calcium carbonate equivalent was determined by referring manometer readings to a curve prepared from standard samples of calcium carbonate. Organ carbon x 1.7 equals the organic matter content.

The results of the clay mineral analyses are given in table 10. Illite and kaolinite are the most abundant minerals in all of the soils except in the lower part of the Sanpete.

In the Ravola, Penoyer, and Billings soils, the Penoyer alone has montmorillonite present in greater than trace amounts in the surface soil. This is probably a result of the greater variety of parent material in which the Penoyer soils were formed. The Penoyer soils also have the higher ratio of cation-exchange capacity to clay, and this difference decreases with depth. The higher ratio suggests that the montmorillonite is present in sufficient quantity to exert an influence on the cation-exchange capacity.

In all of these profiles the montmorillonite content increases with depth. Based upon the reactions and properties observed, allophane or some X-amorphous compounds are present in the Ravola and Sanpete soils.

# *Additional Facts About the Carbon-Emery Area*

This section describes the early settlement, physiography, relief, drainage, geology, water supply, and climate of the Carbon-Emery Area.

## Early Settlement

The remains of cliff dwellings, campsites, burial grounds, and petroglyphs are evidences of early habitation in Carbon and Emery Counties by people who had an advanced cultural development. Francisco Vasquez de Coronado and his army may have been the first white men to see the area that is now Emery County.

Hunters, trappers, and Indians were the main settlers or travelers in Castle Valley from 1850 to 1882. In 1861, Brigham Young sent a prospecting and surveying party from Sanpete County to explore the area east of the Wasatch Mountain Range. The party went as far as Moab and found the area suitable only for hunting and trapping. Castle Valley was a favorite rendezvous for the Ute Indians prior to 1870.

Mormons, under the leadership of Orange Seeley, settled in Castle Dale and Orangeville about 1877. This area was chosen for settlement because of its good supply of water. The settlers were emigrants, mainly from Denmark.

The first settlement near Price was made in October 1877, and settlers started farming along the Price River in January 1879. During that year, Jefferson Tidwell and others settled at Dead Horse Crossing, which is 4 miles east of the present site of Price. Settlers on this part of the river built the first dam across the Price River to divert water for irrigation. The Denver and Rio Grande

Western Railroad was completed in 1883, and trains started running through Carbon County that year.

Emery County was established in 1880; Grand County, in 1890; and Carbon County, in 1894. The total population of Emery County in 1960 was 5,546; that of Carbon County, 21,135. Both counties had a greater population in 1950 than in 1960. Most of the people in these counties live in Castle Valley, near the eastern slopes of the Wasatch Mountains. A few people live at Green River and in the eastern part of Carbon County.

## Physiography, Relief, and Drainage

The Carbon-Emery Area is in the Colorado physiographic province and is in the northwestern corner of the canyonlands of Utah (*3*). Two distinguishing features of the province are important. The first is that the layers of underlying rocks are approximately horizontal, where in contiguous provinces the strata are folded. In no other province in America are these differences more distinct than here. The second distinguishing feature of the province is its great elevation, which is as much as 11,000 feet. Except for canyons very little of the province has an elevation of less than 5,000 feet. Another feature of the entire province is its remarkable number of canyons—not one but hundreds.

The Carbon-Emery survey area is in Castle Valley. It is surrounded by mountain ranges or high plateaus. On the west is the Wasatch Plateau, where elevations are as much as 11,000 feet. On the east is the San Rafael Swell, where the highest elevation is about 8,500 feet. The Wasatch Plateau and the San Rafael Swell converge at the southern end of Castle Valley. On the north is the steep south-facing slope of the Tavaputs Plateau, known as the Book Cliffs. Here the highest elevations range from 8,000 to 9,000 feet. In Castle Valley elevations range from about 5,500 feet at Price in the northern end of the valley to about 6,260 feet at Emery in the southern end.

For convenience, the survey area can be divided into three general physiographic areas: Alluvial valleys, consisting of coalescing alluvial fans and stream flood plains; old, high benches and areas that are remnants of a dissected glacial outwash plain; and gently rolling shale hills and remnants of mesas.

Each of the three physiographic sections has a typical kind of relief. The areas of alluvial valleys have a gentle slope to the east, or locally to the northeast and southeast. The old, high-lying benches and mesas also slope to the east. Steep escarpments surround the mesas and form the outer edges of the benches. The gently rolling shale hills and remnants of mesas have irregular gradients that range from gently sloping to steep.

Most of the Carbon-Emery Area is drained by three river systems. Price River flows east near the northern end of the survey area and empties into the Green River. Huntington, Cottonwood, and Ferron Creeks flow east through the central part of the survey area and converge near its eastern edge to form the San Rafael River. The San Rafael River flows east and empties into the Green River. The Muddy, Quitchupah, and Ivie Creeks converge near the southern end of the survey area to form the Muddy River. The Muddy River flows southeast and converges with the Dirty Devil River, which converges with the Colorado River in the southeastern part of Utah.

## Water Supply

Water for irrigation and domestic use comes from the watersheds in the mountains to the west of the survey area. The supply is fairly constant. Late in summer, however, irrigation water frequently is short in supply. Reservoirs have been constructed in the mountains to augment streamflow late in summer. Farms near Price and Wellington and near Miller Creek obtain their irrigation water from the Price River. The average annual streamflow in the Price River is about 56,000 acre feet. The Huntington Creek furnishes irrigation water to Huntington, Cleveland, Elmo, and Lawrence. This stream has a flow of about 62,000 acre feet during the irrigation season. Cottonwood Creek furnishes irrigation water to Orangeville and Castle Dale. It has a flow of about 64,000 acre feet during the irrigation season. Ferron Creek has a flow of about 42,000 acre feet during the irrigation season and furnishes water to Clawson and Ferron.

Ivie and Muddy Creeks supply Emery and Moore with irrigation water. When water is short in supply, crops in the vicinity of Moore are damaged. In some years these creeks furnish enough water for only one irrigation.

All soils in cultivation require irrigation because of the small amount of rainfall. Water for livestock is collected and stored in artificial ponds and reservoirs.

Most of the survey area is underlain by Mancos shale, a non-water-bearing formation. The few water wells drilled into this formation have produced salty water that is fit neither for irrigation nor for domestic use. Only four drilled wells are in the area, and they are near the Book Cliffs.

The quality of irrigation water is variable. Where this water is diverted into the main canals it is of high quality, and the quality usually remains high. In places, however, seepage water that contains a large quantity of soluble salts mixes with the irrigation water and lowers its quality. The amount of salts in the irrigation water is especially critical late in the season when normal streamflow is lowest.

## Climate of the Carbon-Emery Area[6]

The Sierra Nevada, Cascade, and Rocky Mountain ranges influence the climate of the survey area. Storms from the Pacific Ocean cross the Sierra Nevada and Cascade Mountains before they reach Utah. The moisture associated with these storms generally condenses and falls as precipitation in the areas over which clouds rise in crossing the mountains. As a result, the air that reaches Utah is comparatively dry and produces little or no rain. The Rocky Mountains are an effective barrier to cold, continental air masses that move southward from Canada during winter.

On a smaller scale, the Wasatch Mountains that border Carbon and Emery Counties on the west, and the Tavaputs Plateau that borders these counties on the north,

[6] Prepared by the U.S. Weather Bureau State climatologist for Utah.

provide a sheltering effect to the survey area from storms associated with northerly or westerly winds. These topographic features create a "rain shadow" late in fall, in winter, and in spring. In summer and early in fall, these mountains help to develop showers and thunderstorms from the masses of moisture-laden air that occasionally move into the southeastern part of Utah from the Gulf of Mexico. These storms, generally called cloudbursts, produce large quantities of rain in a short time.

The climate of Carbon and Emery Counties is continental and is dry. The average annual precipitation throughout most of the survey area is between 6 and 10 inches per year. In the high mountains west of the area, the annual precipitation may be as much as 30 inches per year, and most of it falls in winter. In the survey area, the main season of rainfall is from late in July through October. The largest amounts fall during the thunderstorm season in August. November is the driest month.

The survey area has an abundance of sunshine and clear skies. Away from the mountains, about 225 days per year are clear, 105 are partly cloudy, and 35 are cloudy.

Winds generally are light to moderate in all seasons of the year. As a rule, the strongest winds blow in spring, at which time moderate to strong winds blow from the south for several days at a time. These winds reduce the effectiveness of precipitation in spring. Extremely strong winds are rare, and they occur with local thunderstorms or storm fronts.

Winters are cold and dry. Generally, from 10 to 20 inches of snowfall is received at the low elevations. The high mountains west of the survey area get several hundred inches of snow per year. January is the coldest month. Its mean temperature is between 18° and 24° F. Temperatures of less than 10 degrees above zero occur 1 year out of 5.

Summers are warm at elevations of less than 5,000 feet. Here, the average temperature in July is near 80° F. At elevations between 6,000 and 7,000 feet, the average temperature in July is 65° to 70° F. In the high mountains west of the survey area, summer temperatures average in the middle fifties.

The extreme variability of climatic conditions in the survey area is shown in table 11 for Green River, Price, and Emery. The probability, in percent, that specified temperatures will occur at these locations before or after the indicated calendar dates are shown in figure 16. The average growing season at Green River extends from May 2 to October 7; in Price, from May 3 to October 3; and in Emery, from May 21 to October 2.

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## Glossary

**Aggregate, soil.** Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

**Alkali soil.** Generally, a highly alkaline soil. Specifically, an alkali soil that has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is reduced.

**Alkaline soil.** A soil that has a pH value greater than 7.0. See also Reaction, soil.

**Alluvial fan.** A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where the gradient lessens abruptly. In the survey area, some alluvial fans are cone shaped and are at the base of mountains.

**Alluvial plain.** A series of alluvial fans that have coalesced.

**Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

**Available water capacity.** The capacity of a soil to retain water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension. By readily available water is meant the amount of water in a soil that plants can obtain from the soil while maintaining rapid growth. It is approximately one-half of the total available water capacity of the root zone.

**Border irrigation.** A method of irrigation in which the lateral surface flow of water is controlled with small earth ridges, called border dikes.

**Calcareous soil.** A soil that contains enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold dilute hydrochloric acid. The following are terms used in this soil survey to describe calcareous soils, and the approximate amounts of lime these soils contain:

| | |
|---|---|
| Slightly calcareous | 1 to 3 percent lime. |
| Moderately calcareous | 3 to 15 percent lime. |
| Strongly calcareous | 15 to 40 percent lime. |
| Very strongly calcareous | 40 percent lime or more. |

**Calcic horizon.** A horizon that contains an accumulation of calcium carbonate or of calcium and magnesium carbonates. The letter designation *ca* is used to indicate such a horizon.

TABLE 11.—*Temperature and precipitation in the Carbon-Emery Area, Utah*

| Month | Temperature | | | | Precipitation | | | |
|---|---|---|---|---|---|---|---|---|
| | Average daily maximum | Average daily minimum | Two years in 10 will have at least 4 days with— Maximum temperature equal to or higher than— | Two years in 10 will have at least 4 days with— Minimum temperature equal to or lower than— | Average total | One year in 10 will have— Less than— | One year in 10 will have— More than— | Snowfall |
| | ° F. | ° F. | ° F. | ° F. | Inches | Inches | Inches | Inches |
| **EMERY (ELEVATION 6,210 FEET)** | | | | | | | | |
| January | 37. 0 | 11. 2 | 50 | 7 | 0. 51 | (1) | 1. 16 | 5. 6 |
| February | 41. 7 | 15. 4 | 55 | 13 | . 54 | (1) | 1. 11 | 5. 5 |
| March | 50. 1 | 23. 3 | 62 | 17 | . 44 | (1) | 1. 00 | 3. 1 |
| April | 59. 4 | 30. 4 | 73 | 26 | . 40 | (1) | 1. 17 | . 7 |
| May | 68. 3 | 38. 2 | 80 | 36 | . 58 | (1) | 1. 78 | . 7 |
| June | 77. 3 | 45. 5 | 87 | 42 | . 47 | (1) | 1. 30 | 0 |
| July | 82. 9 | 52. 3 | 90 | 51 | . 80 | 0. 13 | 2. 14 | 0 |
| August | 80. 7 | 50. 7 | 88 | 50 | 1. 25 | . 12 | 2. 54 | (1) |
| September | 74. 2 | 42. 3 | 84 | 39 | . 90 | (1) | 1. 91 | (1) |
| October | 63. 1 | 32. 6 | 74 | 30 | . 76 | (1) | 2. 64 | . 5 |
| November | 50. 2 | 22. 3 | 61 | 18 | . 35 | (1) | 1. 04 | 1. 8 |
| December | 39. 6 | 14. 3 | 51 | 12 | . 50 | (1) | 1. 14 | 4. 9 |
| Year | 60. 4 | 31. 5 | | | 7. 50 | | | 22. 8 |
| **PRICE (ELEVATION 5,580 FEET)** | | | | | | | | |
| January | 36. 9 | 9. 1 | 50 | 6 | . 81 | . 06 | 1. 60 | 8. 0 |
| February | 47. 3 | 17. 2 | 56 | 16 | . 69 | . 07 | 1. 40 | 6. 3 |
| March | 52. 4 | 25. 6 | 65 | 22 | . 72 | . 02 | 1. 81 | 2. 7 |
| April | 63. 5 | 33. 2 | 78 | 30 | . 65 | . 08 | 1. 86 | . 2 |
| May | 73. 3 | 41. 9 | 85 | 39 | . 66 | . 13 | 1. 45 | . 3 |
| June | 83. 8 | 49. 5 | 93 | 47 | . 73 | (1) | 1. 41 | (1) |
| July | 90. 2 | 56. 2 | 97 | 56 | . 99 | . 14 | 2. 11 | (1) |
| August | 87. 9 | 54. 4 | 95 | 55 | 1. 23 | . 30 | 2. 09 | 0 |
| September | 80. 2 | 45. 6 | 91 | 45 | 1. 05 | . 02 | 2. 38 | (1) |
| October | 67. 3 | 35. 2 | 79 | 32 | . 96 | . 01 | 1. 86 | . 1 |
| November | 51. 2 | 22. 7 | 64 | 21 | . 54 | . 01 | 1. 45 | . 2 |
| December | 40. 0 | 14. 1 | 52 | 12 | . 82 | . 17 | 2. 08 | 7. 4 |
| Year | 59. 5 | 33. 7 | | | 9. 85 | | | 25. 2 |
| **GREEN RIVER (ELEVATION 4,070 FEET)** | | | | | | | | |
| January | 36. 9 | 8. 9 | 51 | −2 | . 37 | . 03 | . 92 | 3. 2 |
| February | 47. 3 | 17. 8 | 62 | 15 | . 41 | . 01 | . 78 | 1. 5 |
| March | 60. 0 | 27. 1 | 73 | 20 | . 39 | (1) | . 92 | . 2 |
| April | 71. 0 | 35. 8 | 87 | 29 | . 46 | . 06 | 1. 02 | . 1 |
| May | 81. 2 | 44. 5 | 93 | 39 | . 45 | . 02 | . 93 | . 1 |
| June | 92. 1 | 52. 0 | 101 | 47 | . 39 | (1) | 1. 52 | 0 |
| July | 98. 5 | 60. 2 | 104 | 55 | . 49 | . 04 | 1. 51 | 0 |
| August | 95. 3 | 57. 8 | 104 | 56 | . 82 | . 09 | 1. 96 | (1) |
| September | 86. 4 | 47. 2 | 99 | 42 | . 69 | (1) | 1. 47 | 0 |
| October | 71. 8 | 34. 8 | 86 | 29 | . 68 | . 02 | 1. 53 | (1) |
| November | 54. 6 | 21. 4 | 66 | 18 | . 44 | (1) | 1. 06 | . 6 |
| December | 40. 8 | 12. 8 | 53 | 10 | . 41 | . 08 | . 75 | 2. 8 |
| Year | 69. 7 | 35. 0 | | | 6. 00 | | | 8. 8 |

1 Trace.

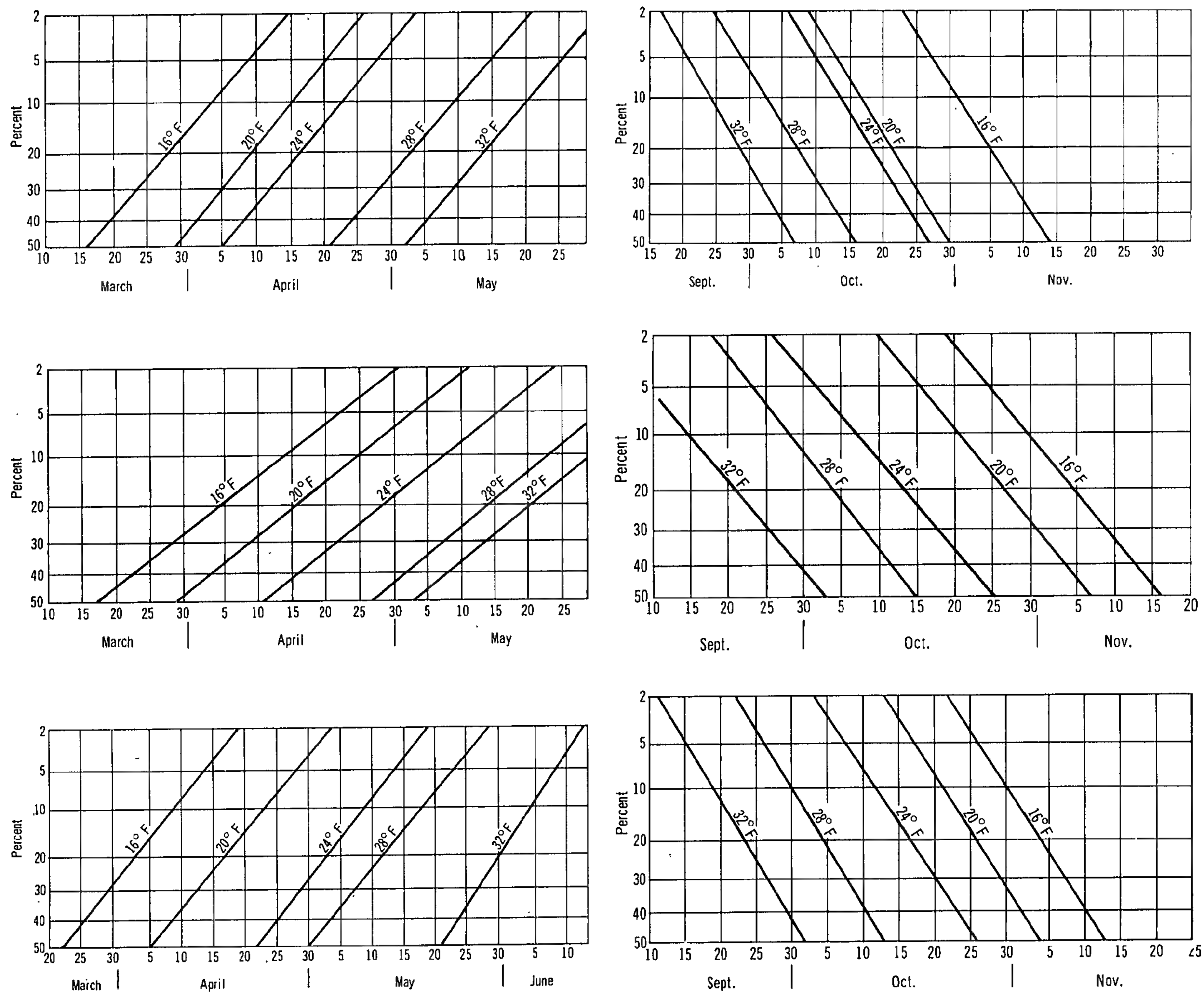


***Figure 16.*—Probabilities of freezing temperature in spring and fall for three places in the Carbon-Emery survey area: Upper pair of charts is for Green River; middle pair is for Price; and lower pair is for Emery.**

**Clay.** As a soil separate, the mineral soil particle less than 0.002 mm. in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Cobblestones.** Rounded fragments of minerals or rocks between 3 and 10 inches in diameter.

**Cobbly soil.** A soil that is 20 to 50 percent coarse fragments, dominantly the size of cobblestones.

**Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistency are:

*Loose.*—Noncoherent; will not hold together in a mass.

*Friable.*—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

*Firm.*—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

*Plastic.*—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

*Sticky.*—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

*Hard.*—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

*Soft.*—When dry, breaks into powder or individual grains under very slight pressure.

*Cemented.*—Hard and brittle; little affected by moistening.

**Depth, soil.** In this survey, the following terms and their meanings are used to describe depth of the soil over bedrock or over a restricting layer:

| | *Depth of soil* |
|---|---|
| Deep | More than 36 inches. |
| Moderately deep | 20 to 30 inches. |
| Shallow | 10 to 20 inches. |
| Very shallow | Less than 10 inches. |

**Drainage, natural.** The relative rapidity and extent of the removal of water from, on, and within the soil under natural conditions. Terms commonly used to describe drainage are—

*Well drained.* Water is removed from the soil readily but not rapidly. Wetness is not apparent above a depth of 40 inches.

*Moderately well drained.* Water is removed from the soil somewhat slowly so that the soil is wet for short, but significant, periods of time.

*Somewhat poorly drained.* Water is removed from the soil slowly enough so that the soil is wet for significant periods but not all the time. Wetness is apparent at depths between 20 and 40 inches.

*Poorly drained.* Water is removed from the soil so slowly that the water table is near the surface most of the time. Wetness is apparent within 20 inches of the surface.

**Erosion hazard.** Susceptibility of a soil to erosion if the cover of plants is removed. Relative terms are *none*, *slight*, *moderate*, and *high*.

**Fertility, soil.** The natural or inherent quality that enables a soil to provide the proper elements and compounds, in the proper quantities and in the proper balance, for the growth of specified plants when other factors, such as light, temperature, and the physical condition of the soil are favorable.

**Gravelly soil.** A soil in which 20 to 50 percent of the solum is coarse fragments between ¼ inch and 3 inches in diameter. A very gravelly soil is one in which more than 50 percent of the solum is coarse fragments the size of gravel.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

**Leaching.** The removal of material in solution by the passage of water through the soil.

**Leveling (of land).** The reshaping or modification of the land surface to a planned grade to provide a more suitable surface for the efficient application of irrigation water and to provide proper surface drainage.

**Mottling, soil.** Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*Few*, *common*, and *many;* size—*fine*, *medium*, and *coarse;* and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these; *Fine*, less than 5 mm. (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 mm. to 15 mm. (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 mm. (about 0.6 inch) in diameter along the greatest dimension.

**Munsell notation.** A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR, a value of 6, and a chroma of 4.

**Nutrients, plant.** The elements that may be taken in by a plant, essential to its growth, and used by it in construction of its food and tissue. Plant nutrients include nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, molybdenum, and perhaps others obtained from the soil, and carbon, hydrogen, and oxygen obtained mainly from air and water.

**Permeability, soil.** That quality of the soil that enables it to transmit water or air. Terms used to describe permeability are the following:

| | *Inches per hour* |
|---|---|
| Very slow | Less than 0.05. |
| Slow | 0.05 to 0.2. |
| Moderately slow | 0.2 to 0.8. |
| Moderate | 0.8 to 2.5. |
| Moderately rapid | 2.5 to 5.0. |
| Rapid | 5.0 to 10.0. |
| Very rapid | More than 10.0. |

**pH value.** A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material. See also Horizon, soil.

**Reaction, soil.** The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degree of acidity or alkalinity are expressed thus:

| | *pH* | | *pH* |
|---|---|---|---|
| Extremely acid | Below 4.5. | Mildly alkaline | 7.4 to 7.8. |
| Very strongly acid. | 4.5 to 5.0. | Moderately alkaline. | 7.9 to 8.4. |
| Strongly acid | 5.1 to 5.5. | Strongly alkaline. | 8.5 to 9.0. |
| Medium acid | 5.6 to 6.0. | Very strongly alkaline. | 9.1 and higher. |
| Slightly acid | 6.1 to 6.5. | | |
| Neutral | 6.6 to 7.3. | | |

**Readily available water.** See Available water capacity.

**Reclamation, soil.** In this survey area, the removal of excess water, salts, and alkali from the soil profile so that the soil is made suitable for crops.

**Roots (abundance of).** Following are terms used to describe abundance of roots: (1) Abundant or many, more than 25 percent of the surface area is penetrated; plentiful, 3 to 25 percent of the surface area is penetrated; few, less than 3 percent of the surface area is penetrated.

**Runoff.** The surface flow of water from an area; or the total volume of surface flow during a specified time.

**Saline soil.** A soil that contains soluble salts in quantities that impair its productivity for plants, but that does not contain an excess of exchangeable sodium. Following are terms for degrees of salinity:

*Slightly saline.* The conductivity of the saturation extract of the soils is 4 to 8 millimhos within 30 inches of the surface.

*Moderately saline.* The conductivity of the saturation extract of the soils is 8 to 16 millimhos within 30 inches of the surface.

*Strongly saline.* The conductivity of the saturation extract is more than 16 millimhos within 30 inches of the surface.

*Very strongly saline.* More than 2 percent of the matrix is total soluble salt.

*Moderately saline-alkali.* Conductivity of the saturation extract of the soils is more than 12 millimhos, and more than 35 percent of the specified area consists of soils that have a percentage of exchangeable sodium of 15 to 30 percent within 30 inches of the surface.

*Strongly saline-alkali.* The conductivity of the saturation extract of the soils is more than 12 millimhos within 30 inches of the surface, and more than 10 percent of the specified area consists of soils that have a percentage of exchangeable sodium greater than 30 percent within 30 inches of the surface.

**Sand.** Individual fragments of rock or minerals in soils having diameters ranging from 0.05 to 2.0 mm. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Silt.** Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm.) to the lower limit of very fine sand (0.05 mm.). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

**Slope classes.** The following slope classes are used in this soil survey:

| | |
|---|---|
| Nearly level | 0 to 1 percent. |
| Gently sloping | 1 to 3 percent. |
| Moderately sloping | 3 to 6 percent. |
| Strongly sloping | 6 to 10 percent. |
| Moderately steep | 10 to 16 percent. |
| Steep | 16 to 30 percent. |
| Very steep | More than 30 percent. |

**Soil.** A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons. Generally, the characteristics of the material in these horizons is unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Stones.** Coarse fragments more than 10 inches in diameter.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal

forms of soil structure are *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

**Subsoil.** Technically, the B horizon; roughly the part of the profile below plow depth.

**Substratum.** Any layer lying beneath the solum, or true soil; the C or R horizon.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Terrace (geological).** An old flood plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. Stream terraces are frequently called *second bottoms*, as contrasted to *flood plains*, and are seldom subject to overflow. Marine terraces were deposited by the sea and generally are wide.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in a mass of soil. (See also Clay, Sand, and Silt). The basic textural classes, in order of increasing proportions of fine particles are as follows: *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

*Coarse-textured soil.*—A soil that contains a large proportion of sand, that is loose and noncoherent when dry, and that is generally relatively low in fertility and in available moisture capacity; highly erodible. Coarse-textured soils are sands and loamy sands.

*Moderately coarse textured soil.*—A soil that has a high content of sand but that contains enough silt and clay to form fragile aggregates; individual grains of sand are easily seen, and the soil mass feels gritty; highly erodible. Moderately coarse textured soils are sandy loams and fine sandy loams.

*Medium-textured soil.*—A soil that generally is friable and easily tilled. Medium-textured soils are very fine sandy loams, loams, silt loams, and silts.

*Moderately fine textured soil.*—A soil that has a texture intermediate between fine and medium. Moderately fine textured soils are clay loams, sandy clay loams, and silty clay loams.

*Fine-textured soil.*—A soil that contains a large proportion of clay; it is normally hard when dry and plastic when wet. Fine-textured soils are sandy clays, silty clays, and clays.

**Topsoil.** A presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

**Water table.** The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone. In this soil survey, reference to a moderately deep water table means that the water table is within 20 to 36 inches of the surface during part of the growing season. Reference to a shallow water table means that the water table is at the surface or is within 20 inches of the surface during part of the growing season.

## GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit or a range site, read the introduction to the section it is in for general information about its management. Other information is given in tables as follows:

Estimated yields, table 1, p. 15.
Engineering uses of soils, tables 3, 4, and 5, pp. 24 through 35.
Acreage and extent, table 6, p. 36.

| Map symbol | Mapping unit | Page | Capability unit: Nonirrigated | Page | Capability unit: Irrigated | Page | Range site: Name | Page |
|---|---|---|---|---|---|---|---|---|
| Ab | Abbott silty clay---------------- | 37 | VIw-2 | 11 | --------- | -- | Wet Meadow | 21 |
| As | Abbott silty clay, strongly saline------------------------ | 38 | VIIw-28 | 12 | --------- | -- | Salt Meadow | 21 |
| Ba | Badland------------------------- | 38 | VIIIs-7 | 14 | --------- | -- | ---------------------- | -- |
| BbB | Beebe loam, 1 to 3 percent slopes------------------------ | 39 | VIIe-D6 | 12 | IVs-26 | 10 | Desert Sandy Loam | 20 |
| BeB | Beebe loamy fine sand, 1 to 3 percent slopes----------------- | 39 | VIIe-D6 | 12 | IVs-26 | 10 | Desert Sandy Loam | 20 |
| BeC2 | Beebe loamy fine sand, 3 to 6 percent slopes, eroded--------- | 39 | VIIe-D6 | 12 | IVs-26 | 10 | Desert Sandy Loam | 20 |
| BfA | Beebe loamy fine sand, extended season, 0 to 1 percent slopes-- | 39 | VIIe-D6 | 12 | IIIs-16 | 9 | Desert Sandy Loam | 20 |
| BlB | Billings silty clay loam, 1 to 3 percent slopes----------------- | 40 | VIIs-D | 13 | IIIe-25 | 9 | Desert Loam Bottom | 19 |
| BlC2 | Billings silty clay loam, 1 to 6 percent slopes, eroded--------- | 40 | VIIe-D | 12 | --------- | -- | Desert Loam Bottom | 19 |
| BsB | Billings silty clay loam, deep watertable, 1 to 3 percent slopes------------------------ | 40 | ------------ | -- | IVs-28 | 11 | ---------------------- | -- |
| BtB | Billings silty clay loam, extended season, 1 to 3 percent slopes----------------- | 40 | ------------ | -- | IIIe-15 | 8 | ---------------------- | -- |
| BuB2 | Billings-Bunderson complex, 1 to 3 percent slopes--------------- | 40 | | | | | | |
| | Billings soil---------------- | -- | VIIe-D | 12 | --------- | -- | Desert Loam Bottom | 19 |
| | Bunderson soil--------------- | -- | VIIIs-7 | 14 | --------- | -- | ---------------------- | -- |
| Ca | Cache silty clay----------------- | 42 | VIIIw-8 | 14 | --------- | -- | ---------------------- | -- |
| CBF2 | Chipeta-Badland association, 3 to 30 percent slopes, eroded--- | 44 | | | | | | |
| | Chipeta soil----------------- | -- | VIIe-D3 | 12 | --------- | -- | Desert Shale | 17 |
| | Badland---------------------- | -- | VIIIs-7 | 14 | --------- | -- | ---------------------- | -- |
| CeE2 | Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded--------- | 43 | VIIs-S3 | 13 | --------- | -- | Semi-Desert Stony Hills (Pinon-Juniper) | 21 |
| CmF2 | Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded- | 43 | VIIe-D3X | 12 | --------- | -- | Desert Red Shale | 17 |
| CPB | Chipeta-Persayo association, 1 to 3 percent slopes------------ | 44 | | | | | | |
| | Chipeta soil----------------- | -- | VIIe-D3 | 12 | VIe-23 | 11 | Desert Shale | 17 |
| | Persayo soil----------------- | -- | VIIe-D4 | 12 | VIe-23 | 11 | Desert Loamy Shale | 18 |
| CPE2 | Chipeta-Persayo association, 3 to 20 percent slopes, eroded--- | 44 | | | | | | |
| | Chipeta soil----------------- | -- | VIIe-D3 | 12 | --------- | -- | Desert Shale | 17 |
| | Persayo soil----------------- | -- | VIIe-D4 | 12 | --------- | -- | Desert Loamy Shale | 18 |
| Fe | Ferron silty clay loam, heavy variant------------------------ | 45 | Vw-2W | 11 | --------- | -- | Wet Meadow | 21 |
| Fr | Ferron silt loam----------------- | 45 | Vw-2W | 11 | --------- | -- | Wet Meadow | 21 |
| Gr | Green River loam----------------- | 46 | ------------ | -- | IIw-1 | 8 | ---------------------- | -- |
| Gu | Gullied land--------------------- | 46 | VIIIe-2 | 13 | --------- | -- | ---------------------- | -- |
| Ha | Harding very fine sandy loam----- | 47 | VIIs-S4 | 13 | --------- | -- | Semi-Desert Limy Loam | 20 |
| Hn | Hunting loam--------------------- | 48 | ------------ | -- | IIIw-2 | 9 | ---------------------- | -- |

| Map symbol | Mapping unit | Page | Capability unit: Nonirrigated | Page | Capability unit: Irrigated | Page | Range site: Name | Page |
|---|---|---|---|---|---|---|---|---|
| Hs | Hunting loam, moderately saline-- | 48 | ------------ | -- | IVs-28 | 11 | --------------------- | -- |
| Hu | Hunting silty clay loam---------- | 48 | ------------ | -- | IIIw-2 | 9 | --------------------- | -- |
| KeE2 | Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded- | 49 | VIIs-SX | 13 | --------- | -- | Semi-Desert Stony Loam (Pinon-Juniper) | 21 |
| KlB | Killpack clay loam, 1 to 3 percent percent slopes----------------- | 50 | VIIs-D | 13 | IVe-25 | 10 | Desert Loam Bottom | 19 |
| KlC2 | Killpack clay loam, 3 to 6 percent slopes, eroded--------- | 50 | VIIe-D | 12 | VIe-23 | 11 | Desert Loam Bottom | 19 |
| KmB | Killpack clay loam, high water-table variant, 1 to 3 percent slopes------------------------ | 50 | VIw-2 | 11 | --------- | -- | Wet Meadow | 21 |
| KpB | Killpack loam, 1 to 3 percent slopes------------------------ | 50 | VIIc-D | 13 | IVe-25 | 10 | Desert Loam Bottom | 19 |
| KpC2 | Killpack loam, 3 to 6 percent slopes, eroded----------------- | 50 | VIIe-D | 12 | VIe-23 | 11 | Desert Loam Bottom | 19 |
| Lb | Libbings silty clay loam--------- | 51 | VIIw-28 | 12 | --------- | -- | Salt Meadow | 21 |
| Ls | Libbings silty clay loam, barren- | 51 | VIIIw-8 | 14 | --------- | -- | --------------------- | -- |
| McB | Minchey clay loam, 1 to 3 percent slopes----------------- | 52 | ------------ | -- | IIe-2 | 6 | --------------------- | -- |
| MlB | Minchey loam, 1 to 3 percent slopes------------------------ | 52 | VIIc-S | 13 | IIe-24 | 7 | Semi-Desert Loam Bench | 20 |
| MsB | Minchey-Sanpete complex, 1 to 3 percent slopes------------------ | 52 | | | | | | |
| | Minchey soil----------------- | -- | VIIc-S | 13 | IIe-24 | 7 | Semi-Desert Loam Bench | 20 |
| | Sanpete soil----------------- | -- | VIIs-S4 | 13 | IVs-24 | 10 | Semi-Desert Limy Loam | 20 |
| MsC2 | Minchey-Sanpete complex, 1 to 6 percent slopes, eroded--------- | 52 | | | | | | |
| | Minchey soil----------------- | -- | VIIe-S4 | 12 | IIe-24 | 7 | Semi-Desert Loam Bench | 20 |
| | Sanpete soil----------------- | -- | VIIs-S4 | 13 | IVs-24 | 10 | Semi-Desert Limy Loam | 20 |
| Mx | Mixed alluvial land-------------- | 53 | VIw-2 | 11 | --------- | -- | Wet Stream Bottom | 23 |
| PaB | Palisade loam, high watertable variant, 1 to 3 percent slopes- | 54 | Vw-2W | 11 | --------- | -- | Wet Meadow | 21 |
| PCE2 | Persayo-Chipeta association, 1 to 20 percent slopes, eroded------ | 57 | | | | | | |
| | Persayo soil----------------- | -- | VIIe-D4 | 12 | ---------- | -- | Desert Loamy Shale | 18 |
| | Chipeta soil ----------------- | -- | VIIe-D3 | 12 | --------- | -- | Desert Shale | 17 |
| PdB | Palisade very fine sandy loam, 1 to 3 percent slopes---------- | 53 | VIIc-S | 13 | IIe-24 | 7 | Semi-Desert Loam Bench | 20 |
| PdC2 | Palisade very fine loam, 3 to 6 percent slopes, eroded--------- | 54 | VIIe-S | 12 | IIIe-2 | 8 | Semi-Desert Loam Bench | 20 |
| PeB | Penoyer loam, 1 to 3 percent slopes------------------------ | 55 | VIIc-D | 13 | IIe-2 | 6 | Desert Loam Bottom | 19 |
| PeC2 | Penoyer loam, 3 to 6 percent slopes, eroded----------------- | 55 | VIIe-D | 12 | IIIe-2 | 8 | Desert Loam Bottom | 19 |
| PhD | Penoyer loam, 1 to 10 percent slopes, channeled-------------- | 55 | VIIe-D | 12 | --------- | -- | Desert Loam Bottom | 19 |
| PnA | Penoyer loam, extended season, 0 to 1 percent slopes----------- | 55 | ------------ | -- | I-1 | 6 | --------------------- | -- |
| PoB | Penoyer silty clay loam, 1 to 3 percent slopes----------------- | 56 | VIIs-D | 13 | IIe-2 | 6 | Desert Loam Bottom | 19 |
| PrA | Penoyer silty clay loam, extended season, 0 to 1 percent slopes-- | 56 | ------------ | -- | I-1 | 6 | --------------------- | -- |
| PsB | Penoyer very fine sandy loam, 1 to 3 percent slopes----------- | 56 | VIIc-D | 13 | IIe-2 | 6 | Desert Sandy Loam | 20 |
| PsC2 | Penoyer very fine sandy loam, 3 to 6 percent slopes, eroded---- | 56 | VIIe-D6 | 12 | IIIe-2 | 8 | Desert Sandy Loam | 20 |
| PvB2 | Penoyer very fine sandy loam, alkali, 1 to 3 percent slopes, eroded------------------------- | 56 | VIIe-D6 | 12 | IVs-28 | 11 | Desert Sandy Loam | 20 |
| Ra | Rafael silty clay loam---------- | 58 | VIIw-28 | 12 | --------- | -- | Wet Meadow | 21 |

| Map symbol | Mapping unit | Page | Capability unit: Nonirrigated | Page | Capability unit: Irrigated | Page | Range site: Name | Page |
|---|---|---|---|---|---|---|---|---|
| RlB | Ravola loam, 1 to 3 percent slopes------------------------ | 59 | VIIc-D | 13 | IIe-2 | 6 | Desert Loam Bottom | 19 |
| RlB2 | Ravola loam, 1 to 3 percent slopes, eroded----------------- | 59 | VIIe-D | 12 | IIe-2 | 6 | Desert Loam Bottom | 19 |
| RlC2 | Ravola loam, 3 to 6 percent slopes, eroded----------------- | 59 | VIIe-D | 12 | IIIe-2 | 8 | Desert Loam Bottom | 19 |
| RnD | Ravola loam, 1 to 10 percent slopes, channeled------------- | 59 | VIIe-D | 12 | --------- | -- | Desert Loam Bottom | 19 |
| RsA | Ravola loam, extended season, 0 to 1 percent slopes---------- | 59 | ------------- | -- | I-1 | 6 | --------------------- | -- |
| RsB | Ravola loam, extended season, 1 to 3 percent slopes---------- | 59 | ------------- | -- | IIe-1 | 6 | --------------------- | -- |
| RtB | Ravola silty clay loam, 1 to 3 percent slopes----------------- | 59 | VIIs-D | 13 | IIe-2 | 6 | Desert Loam Bottom | 19 |
| RuB2 | Ravola-Bunderson complex, 1 to 3 percent slopes, eroded--------- | 59 | | | | | | |
| | Ravola soil------------------ | -- | VIIe-D | 12 | --------- | -- | Desert Loam Bottom | 19 |
| | Bunderson soil--------------- | -- | VIIe-D | 12 | --------- | -- | --------------------- | -- |
| Rv | Riverwash------------------------ | 60 | VIIIw-4 | 14 | --------- | -- | --------------------- | -- |
| Ry | Rock land------------------------ | 60 | VIIIs-3 | 14 | --------- | -- | --------------------- | -- |
| Sa | Saltair silty clay loam---------- | 61 | VIIw-28 | 12 | --------- | -- | Salt Meadow | 21 |
| Sb | Saltair silty clay loam, barren------------------------ | 61 | VIIIw-8 | 14 | --------- | -- | -------------------- | -- |
| SlB | Sanpete sandy clay loam, 1 to 3 percent slopes----------------- | 62 | VIIs-S4 | 13 | IVs-24 | 10 | Semi-Desert Limy Loam | 20 |
| SlD2 | Sanpete sandy clay loam, 3 to 10 percent slopes, eroded--------- | 62 | VIIs-S4 | 13 | IVs-24 | 10 | Semi-Desert Limy Loam | 20 |
| SmD2 | Sanpete-Minchey complex, 1 to 10 percent slopes, eroded--------- | 62 | | | | | | |
| | Sanpete soil----------------- | -- | VIIs-S4 | 13 | IVs-24 | 10 | Semi-Desert Limy Loam | 20 |
| | Minchey soil----------------- | -- | VIIe-S4 | 12 | IIe-24 | 7 | Semi-Desert Limy Loam | 20 |
| Sn | Shaly colluvial land------------- | 62 | VIIs-DX | 13 | --------- | -- | Desert Cobbly Loam | 19 |
| St | Stony alluvial land-------------- | 62 | VIIs-SX | 13 | --------- | -- | Semi-Desert Stony Loam (Pinon-Juniper) | 21 |
| Wo | Woodrow silty clay loam---------- | 63 | VIIs-D | 13 | IIe-2 | 6 | Desert Loam Bottom | 19 |

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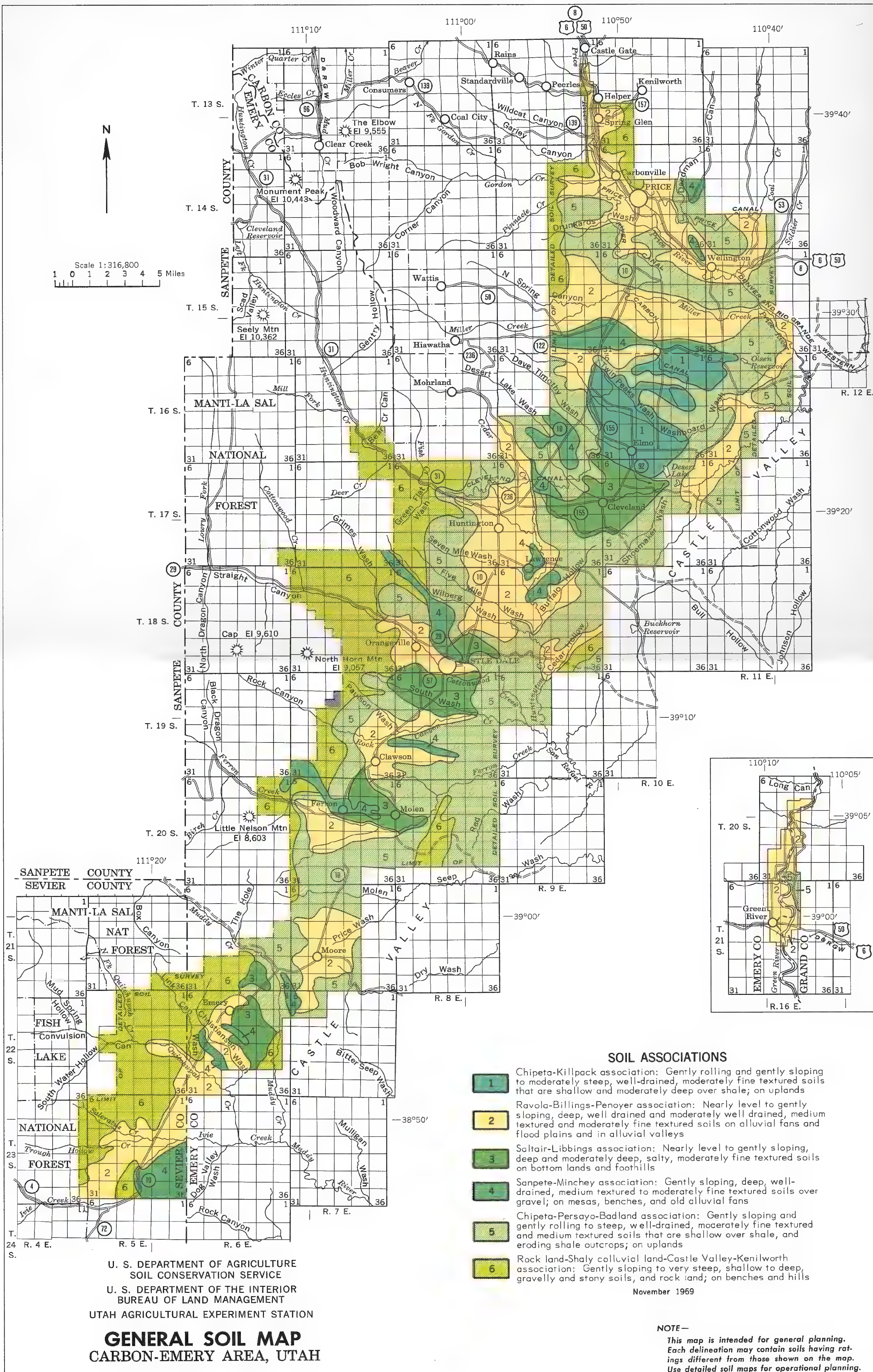



## SOIL ASSOCIATIONS

1 — Chipeta-Killpack association: Gently rolling and gently sloping to moderately steep, well-drained, moderately fine textured soils that are shallow and moderately deep over shale; on uplands

2 — Ravola-Billings-Penoyer association: Nearly level to gently sloping, deep, well drained and moderately well drained, medium textured and moderately fine textured soils on alluvial fans and flood plains and in alluvial valleys

3 — Saltair-Libbings association: Nearly level to gently sloping, deep and moderately deep, salty, moderately fine textured soils on bottom lands and foothills

4 — Sanpete-Minchey association: Gently sloping, deep, well-drained, medium textured to moderately fine textured soils over gravel; on mesas, benches, and old alluvial fans

5 — Chipeta-Persayo-Badland association: Gently sloping and gently rolling to steep, well-drained, moderately fine textured and medium textured soils that are shallow over shale, and eroding shale outcrops; on uplands

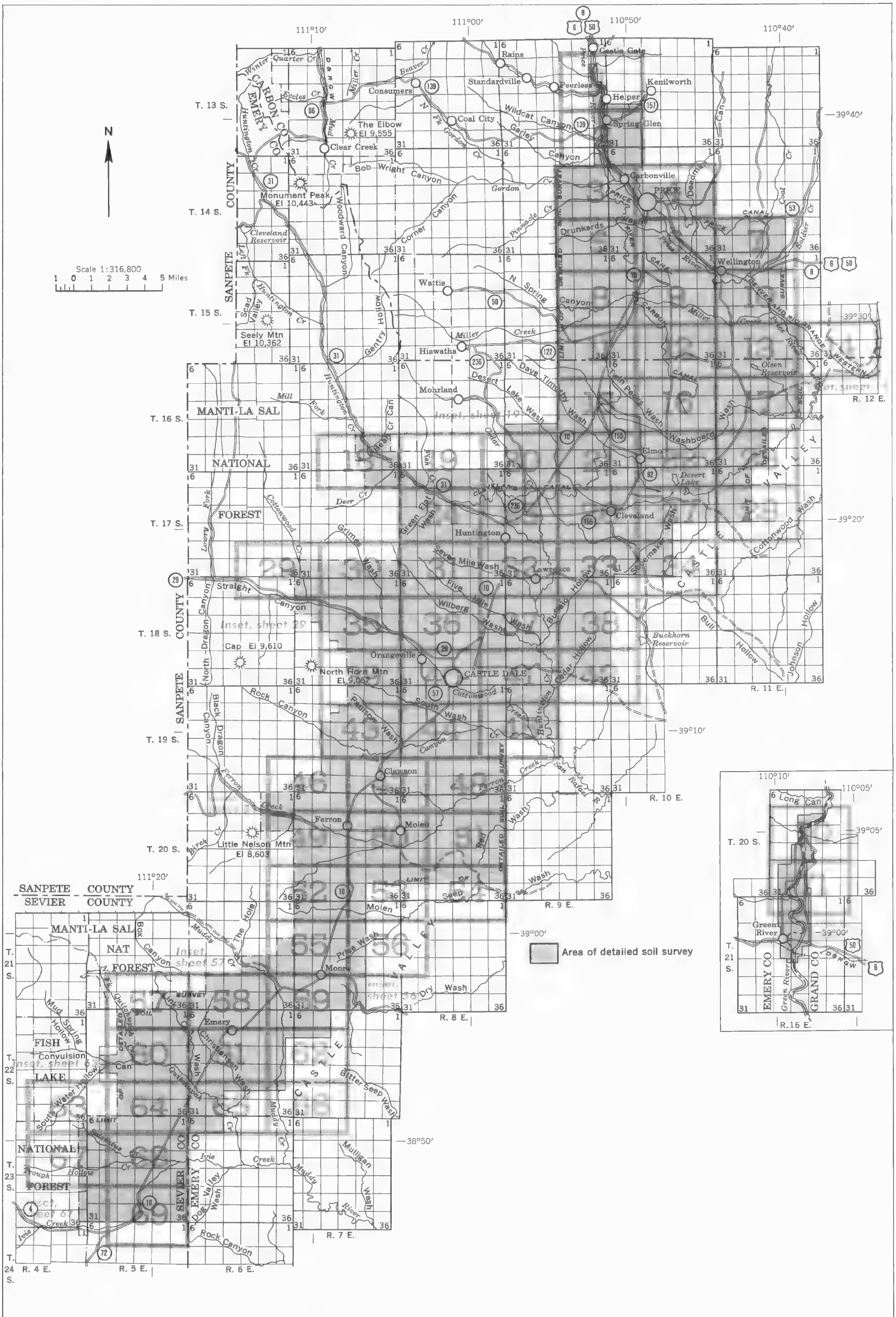
6 — Rock land-Shaly colluvial land-Castle Valley-Kenilworth association: Gently sloping to very steep, shallow to deep, gravelly and stony soils, and rock land; on benches and hills

November 1969

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
UTAH AGRICULTURAL EXPERIMENT STATION

# GENERAL SOIL MAP
## CARBON-EMERY AREA, UTAH

*NOTE—*
***This map is intended for general planning. Each delineation may contain soils having ratings different from those shown on the map. Use detailed soil maps for operational planning.***




INDEX TO MAP SHEETS
CARBON-EMERY AREA, UTAH

U. S. DEPARTMENT OF AGRICULTURE
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BUREAU OF LAND MANAGEMENT
UTAH AGRICULTURAL EXPERIMENT STATION

# CONVENTIONAL SIGNS

## WORKS AND STRUCTURES

- Highways and roads
  - Dual
  - Good motor
  - Poor motor
  - Trail
- Highway markers
  - National Interstate
  - U. S.
  - State or county
- Railroads
  - Single track
  - Multiple track
  - Abandoned
- Bridges and crossings
  - Road
  - Trail
  - Railroad
  - Ferry (FY)
  - Ford (FORD)
  - Grade
  - R. R. over
  - R. R. under
- Tunnel
- Buildings
  - School
  - Church
- Mine and quarry
- Gravel pit
- Power line
- Pipeline
- Cemetery
- Dams
- Levee
- Tanks
- Well, oil or gas
- Forest fire or lookout station
- Windmill

## BOUNDARIES

- National or state
- County
- Project area
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

## DRAINAGE

- Streams, double-line
  - Perennial
  - Intermittent
- Streams, single-line
  - Perennial
  - Intermittent
    - Crossable with tillage implements
    - Not crossable with tillage implements
  - Unclassified
- Canals and ditches (CANAL)
- Lakes and ponds
  - Perennial (water, w)
  - Intermittent
- Spring
- Marsh or swamp
- Wet spot
- Alluvial fan
- Drainage end

## RELIEF

- Escarpments
  - Bedrock
  - Other
- Prominent peak
- Depressions (Large, Small)
  - Crossable with tillage implements
  - Not crossable with tillage implements
  - Contains water most of the time

## SOIL SURVEY DATA

- Soil boundary
  - and symbol (Dx)
- Gravel
- Stoniness
  - Stony
  - Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Saline spot
- Wind hummock or small dune

## SOIL LEGEND

The first capital letter is the initial one of the soil name. The second letter is a capital if the mapping unit is an association; otherwise it is a small letter. The third letter, always a capital A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are for nearly level soils or land types, but some are for land types, for example Rock land, that have a considerable range in slope. A final number, 2, in a symbol shows that the soil is eroded.

### DETAILED SURVEY

| SYMBOL | NAME |
|---|---|
| Ab | Abbott silty clay |
| As | Abbott silty clay, strongly saline |
| Ba | Badland |
| BbB | Beebe loam, 1 to 3 percent slopes |
| BeB | Beebe loamy fine sand, 1 to 3 percent slopes |
| BeC2 | Beebe loamy fine sand, 3 to 6 percent slopes, eroded |
| BfA | Beebe loamy fine sand, extended season, 0 to 1 percent slopes |
| BlB | Billings silty clay loam, 1 to 3 percent slopes |
| BlC2 | Billings silty clay loam, 1 to 6 percent slopes, eroded |
| BsB | Billings silty clay loam, deep watertable, 1 to 3 percent slopes |
| BtB | Billings silty clay loam, extended season, 1 to 3 percent slopes |
| BuB2 | Billings–Bunderson complex, 1 to 3 percent slopes, eroded |
| Ca | Cache silty clay |
| CBF2 | Chipeta–Badland association, 3 to 30 percent slopes, eroded |
| CeE2 | Castle Valley extremely rocky very fine sandy loam, 0 to 20 percent slopes, eroded |
| CmF2 | Cedar Mountain shaly clay loam, 3 to 30 percent slopes, eroded |
| CPB | Chipeta–Persayo association, 1 to 3 percent slopes |
| CPE2 | Chipeta–Persayo association, 3 to 20 percent slopes, eroded |
| Fe | Ferron silty clay loam, heavy variant |
| Fr | Ferron silt loam |
| Gr | Green River loam |
| Gu | Gullied land |
| Ha | Harding very fine sandy loam |
| Hn | Hunting loam |
| Hs | Hunting loam, moderately saline |
| Hu | Hunting silty clay loam |
| KeE2 | Kenilworth very stony sandy loam, 0 to 20 percent slopes, eroded |
| KlB | Killpack clay loam, 1 to 3 percent slopes |
| KlC2 | Killpack clay loam, 3 to 6 percent slopes, eroded |
| KmB | Killpack clay loam, high watertable variant, 1 to 3 percent slopes |
| KpB | Killpack loam, 1 to 3 percent slopes |
| KpC2 | Killpack loam, 3 to 6 percent slopes, eroded |
| Lb | Libbings silty clay loam |
| Ls | Libbings silty clay loam, barren |

| SYMBOL | NAME |
|---|---|
| McB | Minchey clay loam, 1 to 3 percent slopes |
| MlB | Minchey loam, 1 to 3 percent slopes |
| MsB | Minchey–Sanpete complex, 1 to 3 percent slopes |
| MsC2 | Minchey–Sanpete complex, 1 to 6 percent slopes, eroded |
| Mx | Mixed alluvial land |
| PaB | Palisade loam, high watertable variant, 1 to 3 percent slopes |
| PCE2 | Persayo–Chipeta association, 1 to 20 percent slopes, eroded |
| PdB | Palisade very fine sandy loam, 1 to 3 percent slopes |
| PdC2 | Palisade very fine sandy loam, 3 to 6 percent slopes, eroded |
| PeB | Penoyer loam, 1 to 3 percent slopes |
| PeC2 | Penoyer loam, 3 to 6 percent slopes, eroded |
| PhD | Penoyer loam, 1 to 10 percent slopes, channeled |
| PnA | Penoyer loam, extended season, 0 to 1 percent slopes |
| PoB | Penoyer silty clay loam, 1 to 3 percent slopes |
| PrA | Penoyer silty clay loam, extended season, 0 to 1 percent slopes |
| PsB | Penoyer very fine sandy loam, 1 to 3 percent slopes |
| PsC2 | Penoyer very fine sandy loam, 3 to 6 percent slopes, eroded |
| PvB2 | Penoyer very fine sandy loam, alkali, 1 to 3 percent slopes, eroded |
| Ra | Rafael silty clay loam |
| RlB | Ravola loam, 1 to 3 percent slopes |
| RlB2 | Ravola loam, 1 to 3 percent slopes, eroded |
| RlC2 | Ravola loam, 3 to 6 percent slopes, eroded |
| RnD | Ravola loam, 1 to 10 percent slopes, channeled |
| RsA | Ravola loam, extended season, 0 to 1 percent slopes |
| RsB | Ravola loam, extended season, 1 to 3 percent slopes |
| RtB | Ravola silty clay loam, 1 to 3 percent slopes |
| RuB2 | Ravola–Bunderson complex, 1 to 3 percent slopes, eroded |
| Rv | Riverwash |
| Ry | Rock land |
| Sa | Saltair silty clay loam |
| Sb | Saltair silty clay loam, barren |
| SlB | Sanpete sandy clay loam, 1 to 3 percent slopes |
| SlD2 | Sanpete sandy clay loam, 3 to 10 percent slopes, eroded |
| SmD2 | Sanpete–Minchey complex, 1 to 10 percent slopes, eroded |
| Sn | Shaly colluvial land |
| St | Stony alluvial land |
| Wo | Woodrow silty clay loam |

Soil map constructed 1968 by Cartographic Division, Soil Conservation Service, USDA, from 1958, 1961 and 1962 aerial photographs. Controlled mosaic based on Utah plane coordinate system, central zone, Lambert conformal conic projection, 1927 North American datum.

1


(Joins sheet 2)

N

Scale 1:20000

1 Mile
5000 Feet
0 ¼ ½ ¾ 1
0 1000 2000 3000 4000 5000

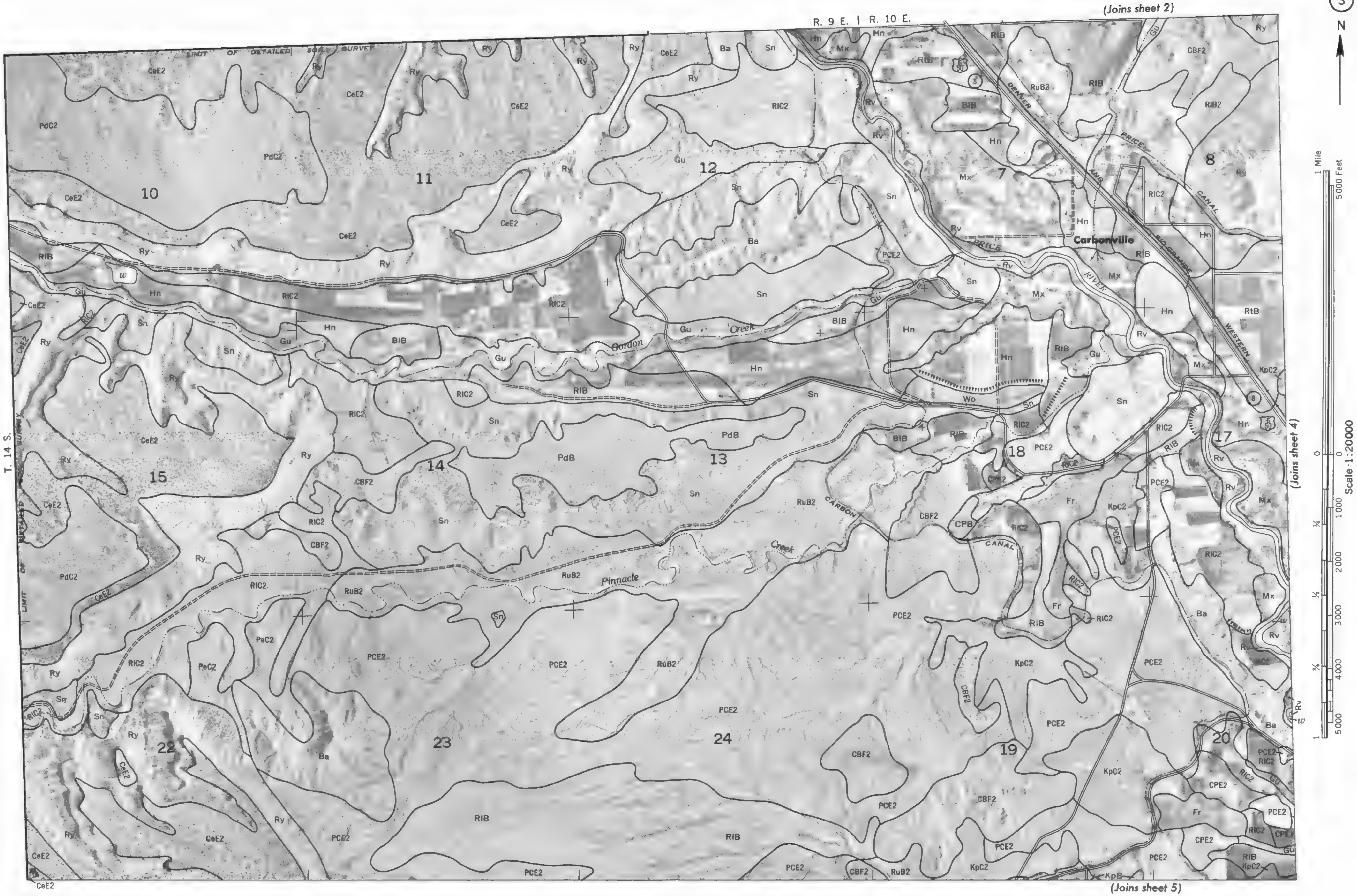
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.
CARBON-EMERY AREA, UTAH NO. 1

CARBON-EMERY AREA, UTAH — SHEET NUMBER 2


CARBON-EMERY AREA, UTAH NO. 2

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 3

CARBON-EMERY AREA, UTAH — SHEET NUMBER 4

4

N

(Joins sheet 2)

R. 10 E.

Scale 1:20000

(Joins sheet 3)

1 Mile 5000 Feet 0 1000 2000 3000 4000 5000

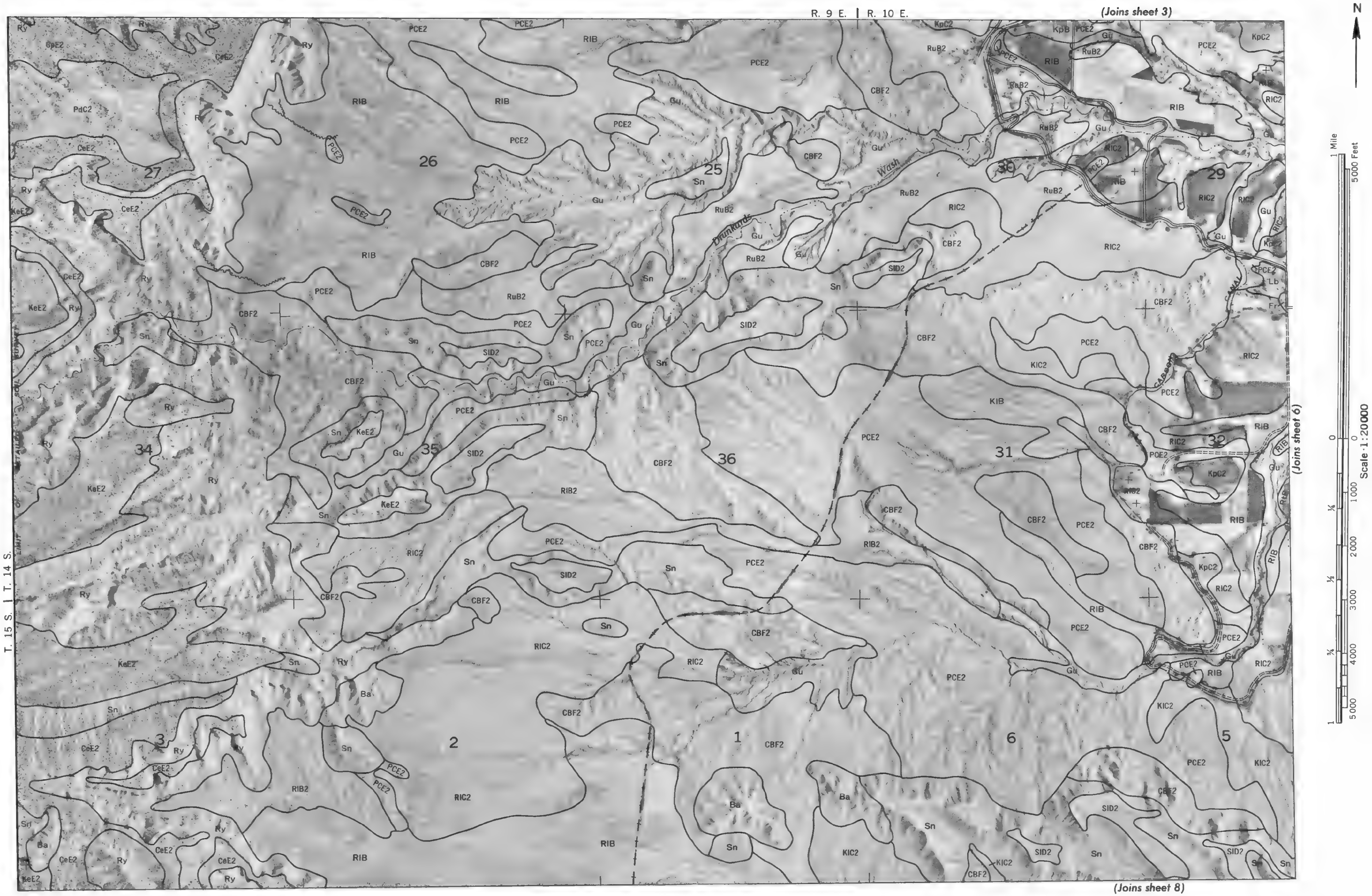

(Joins sheet 6)

CARBON-EMERY AREA, UTAH NO. 4

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

5



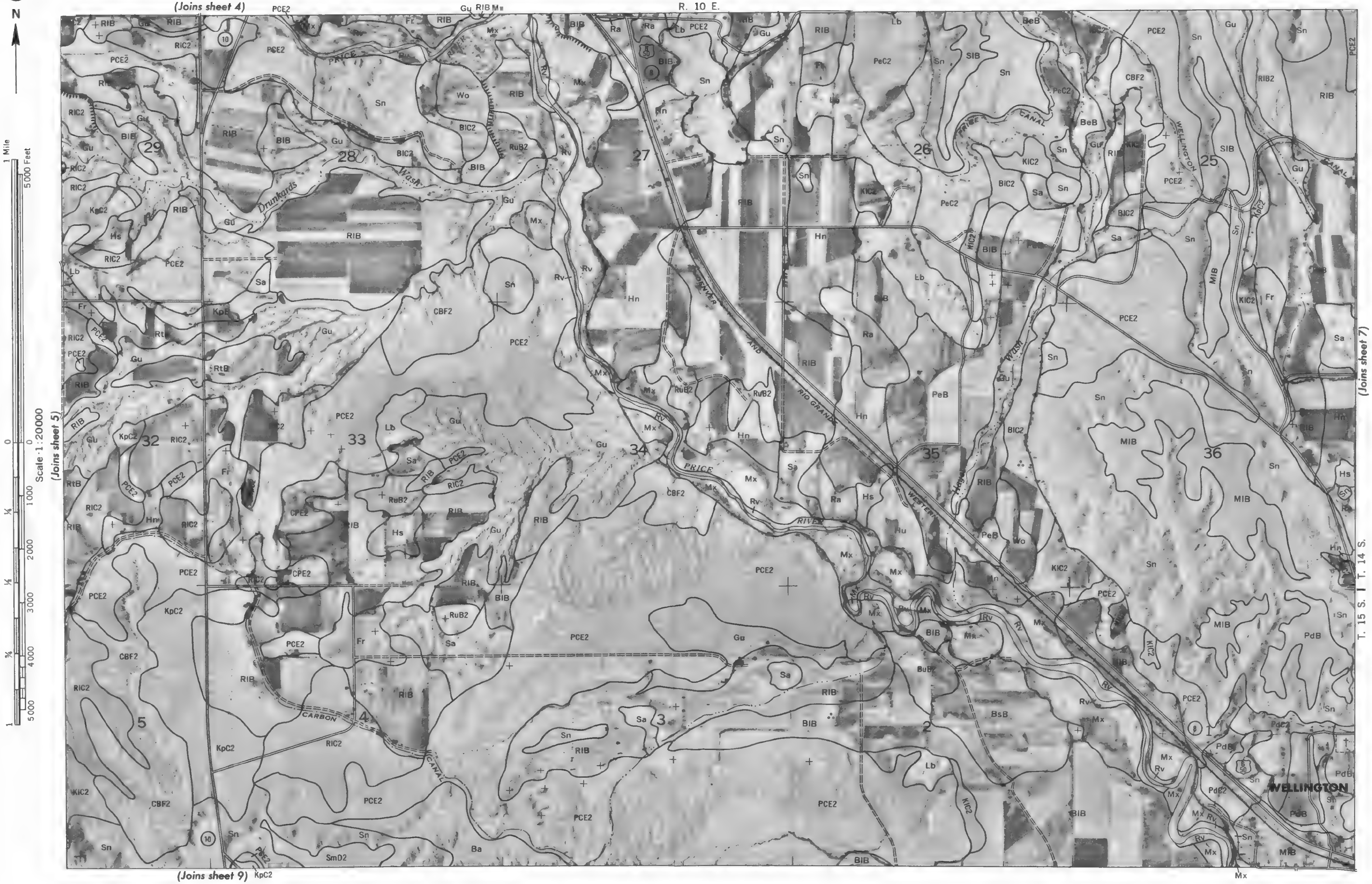

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 5

6

# CARBON-EMERY AREA, UTAH — SHEET NUMBER 6



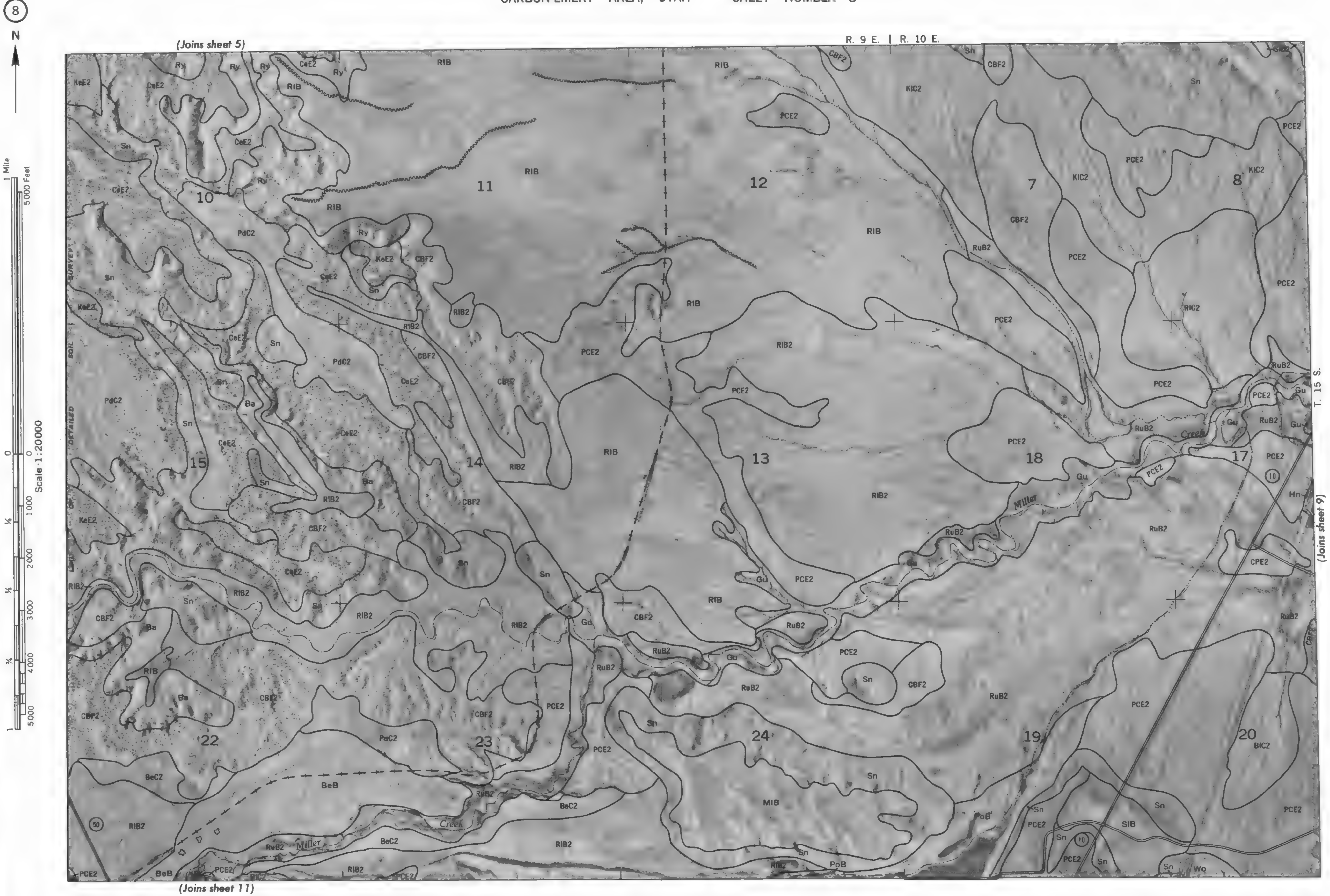

CARBON-EMERY AREA, UTAH NO. 6

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 7

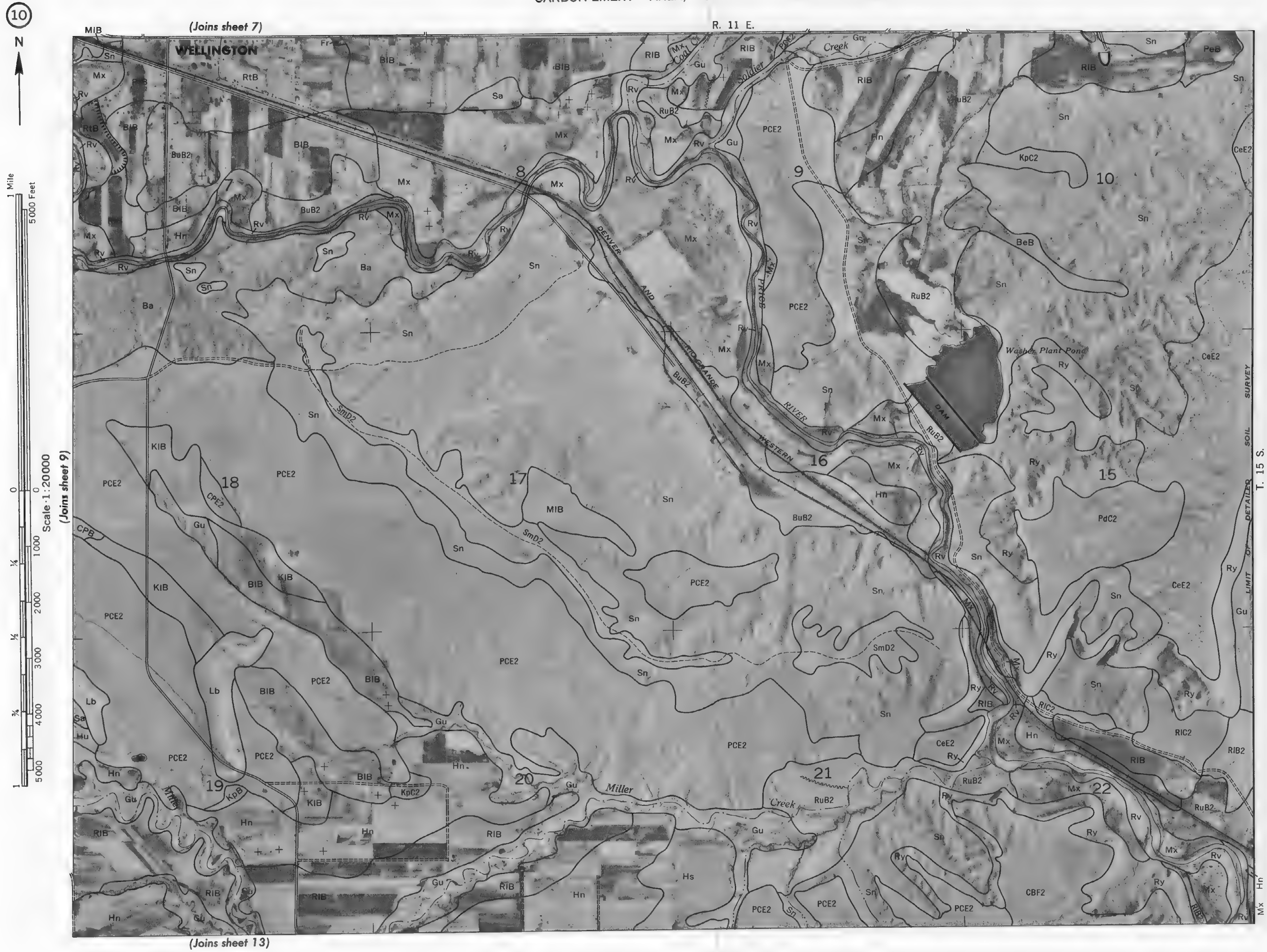


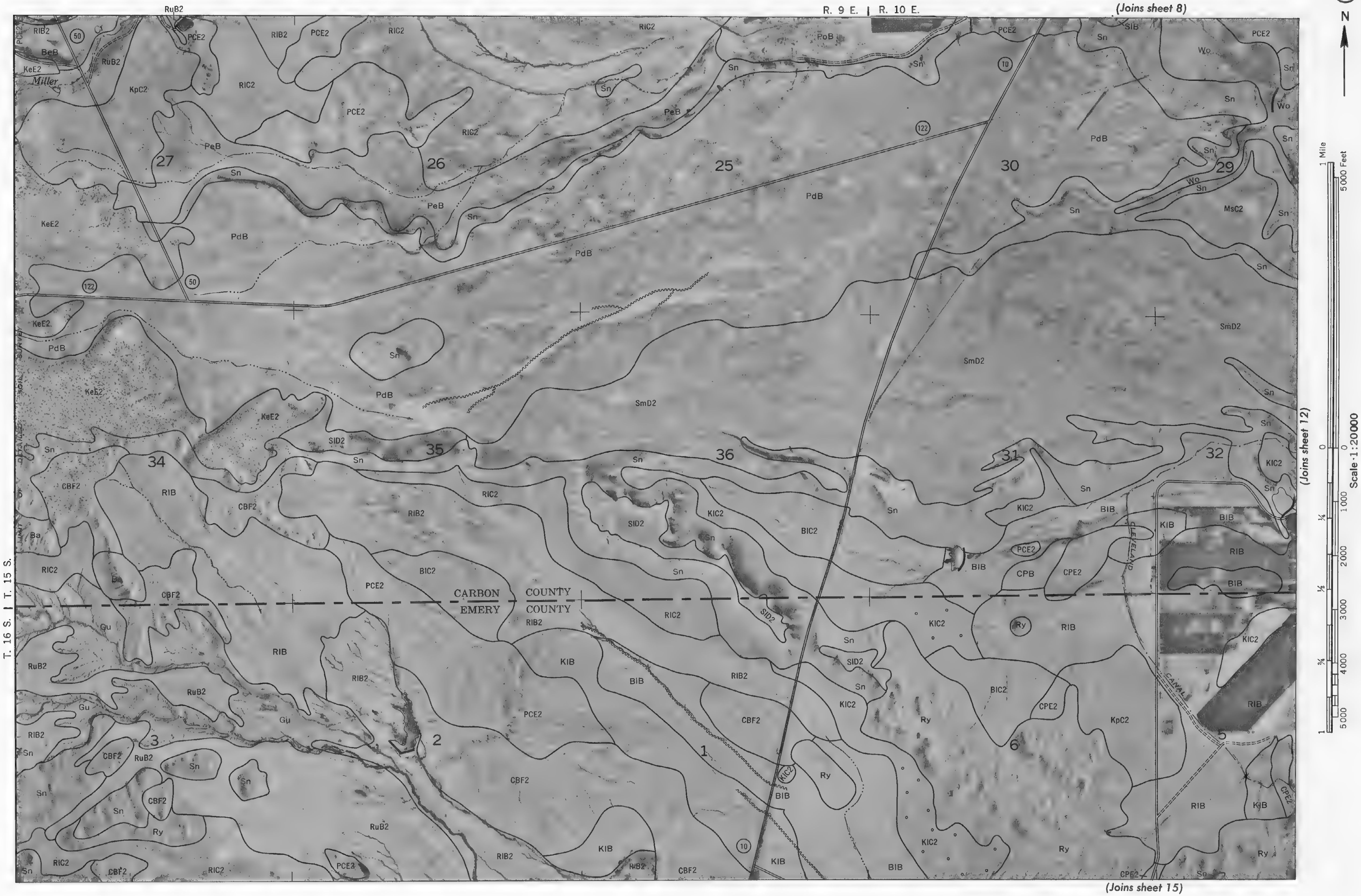

CARBON-EMERY AREA, UTAH NO. 8

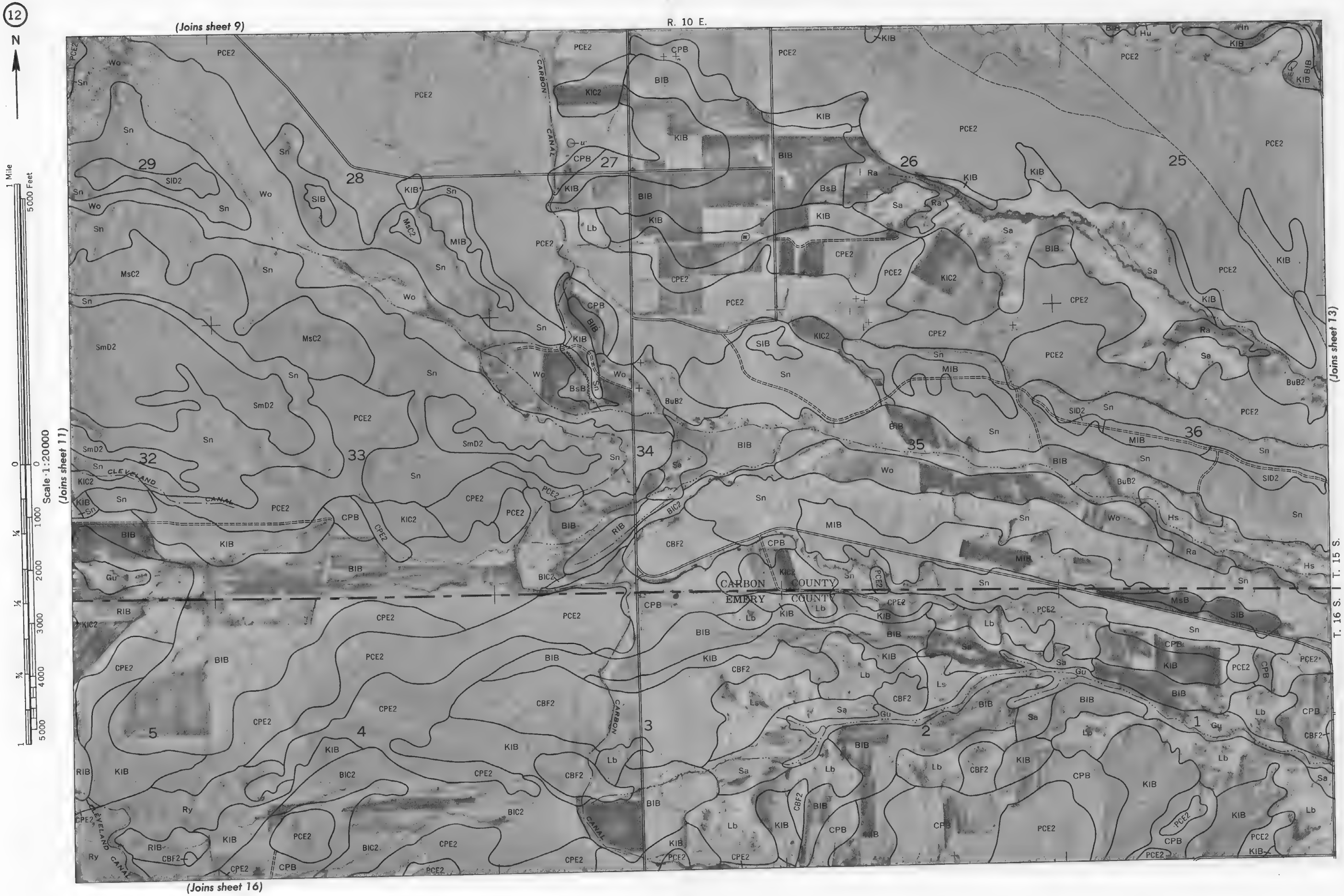
Land division corners are approximately positioned on this map.

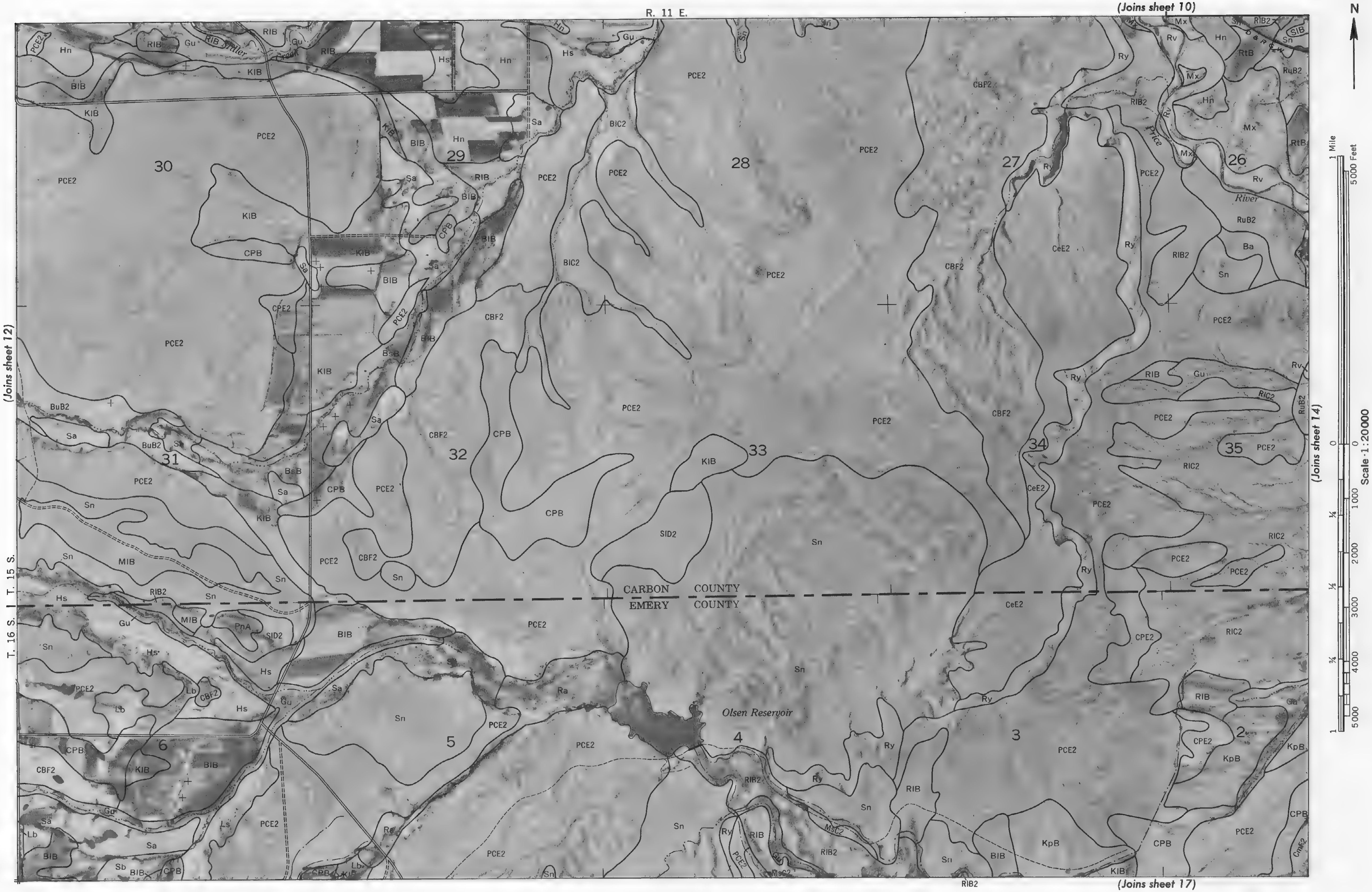
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

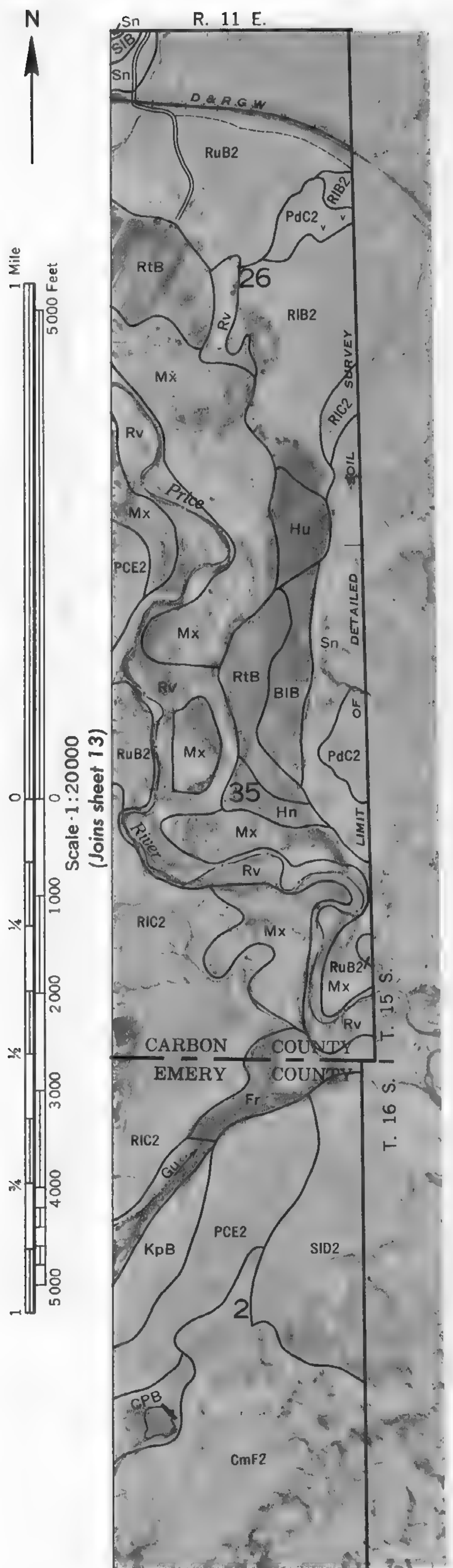

R. 10 E.
(Joins sheet 6)
(Joins sheet 8)
(Joins sheet 10)
(Joins sheet 12)
T. 15 S.
N
1 Mile
5000 Feet
Scale 1:20000
8
9
10
11
12
13
14
15
16
17
20
21
22
23
24
CARBON CANAL
PRICE
Miller Creek
PCE2
RIB
KpC2
Sn
SmD2
CPE2
CBF2
BIB
KIB
Lb
Sa
Gu
Hn
Hs
RuB2
RIC2
CPB
Mx
Rv


10
N
(Joins sheet 7)
R. 11 E.
WELLINGTON
Coal Cr.
Soldier Creek
DENVER AND RIO GRANDE WESTERN
PRICE RIVER
Washer Plant Pond
DAM
Miller Creek
LIMIT OF DETAILED SOIL SURVEY
T. 15 S.
(Joins sheet 9)
(Joins sheet 13)
Scale 1:20000
1 Mile
5000 Feet


R. 9 E. | R. 10 E.
(Joins sheet 8)
(Joins sheet 12)
(Joins sheet 15)
T. 15 S. | T. 16 S.
N
1 Mile
5000 Feet
Scale 1:20000
CARBON COUNTY
EMERY COUNTY
CLEVELAND
CANAL
Miller
27
26
25
30
29
34
35
36
31
32
3
2
1
6
5


12
N
(Joins sheet 9)
R. 10 E.
(Joins sheet 11)
(Joins sheet 13)
(Joins sheet 16)
T. 15 S.
T. 16 S.
CARBON COUNTY
EMERY COUNTY
CLEVELAND CANAL
CARBON CANAL
Scale 1:20000
1 Mile
5000 Feet
29
28
27
26
25
32
33
34
35
36
5
4
3
2
1

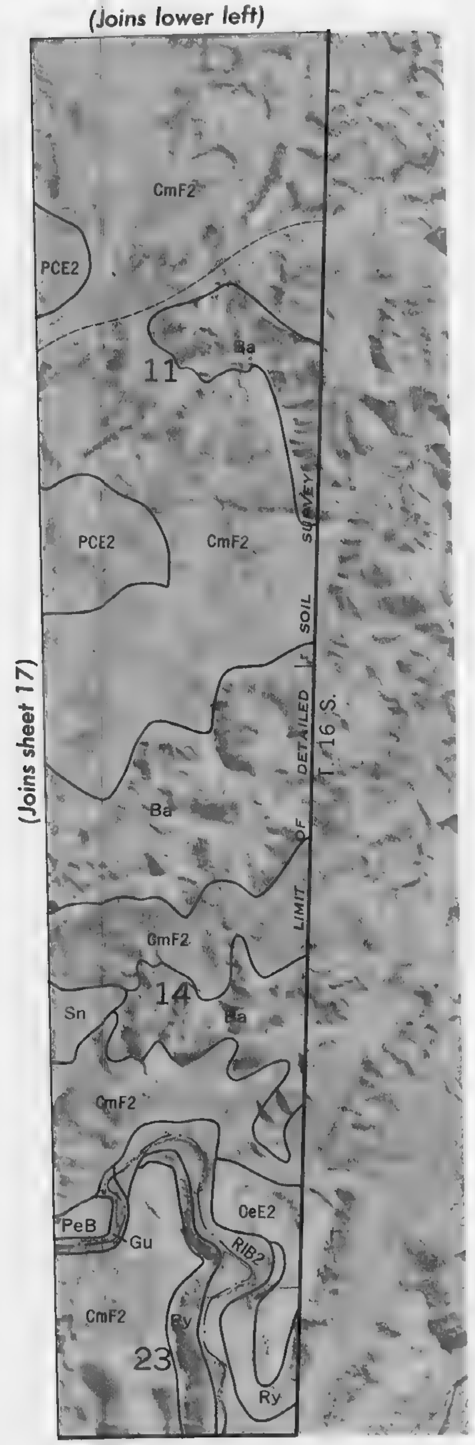

R. 11 E.
(Joins sheet 10)
(Joins sheet 12)
(Joins sheet 14)
(Joins sheet 17)
T. 15 S.
T. 16 S.
N
1 Mile
5000 Feet
Scale 1:20000
CARBON COUNTY
EMERY COUNTY
Olsen Reservoir
Price River
Miller Creek
30
29
28
27
26
31
32
33
34
35
6
5
4
3
2
PCE2
KIB
CPB
CBF2
BIC2
SID2
Sn
Sa
Hs
Hn
Gu
RIB
BIB
MIB
Ry
Rv
Mx
CeE2
RIC2
RIB2
KpB
CPE2
PnA
Lb
Ra




(Joins upper right)

R. 11 E.

(Joins lower left)



(15)

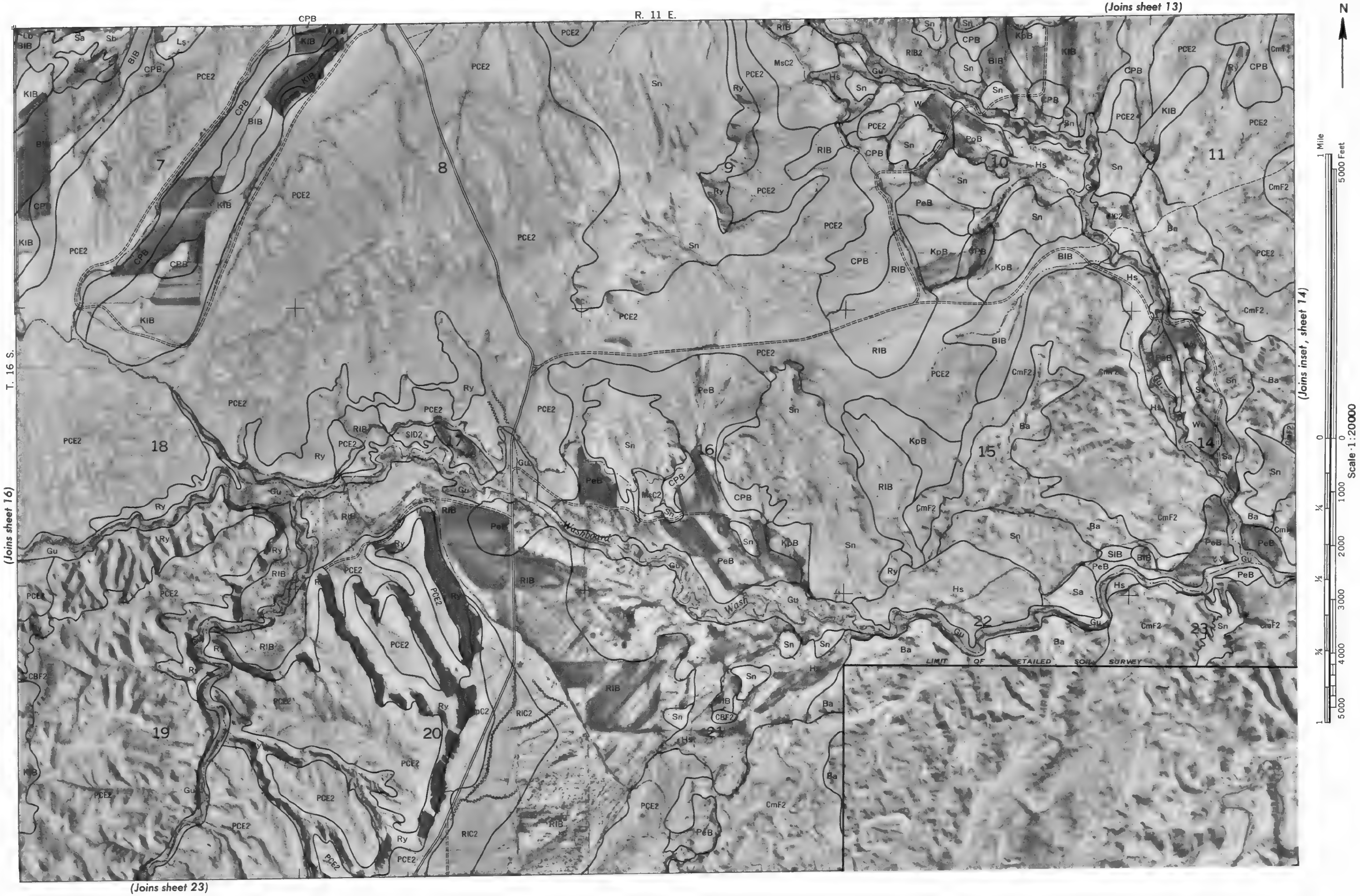



CARBON-EMERY AREA, UTAH NO. 15


CARBON-EMERY AREA, UTAH NO. 16

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 17

(18)

N

Scale 1:20000

1 Mile ¾ ½ ¼ 0

5000 Feet 4000 3000 2000 1000 0


CARBON-EMERY AREA, UTAH NO. 18

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

19

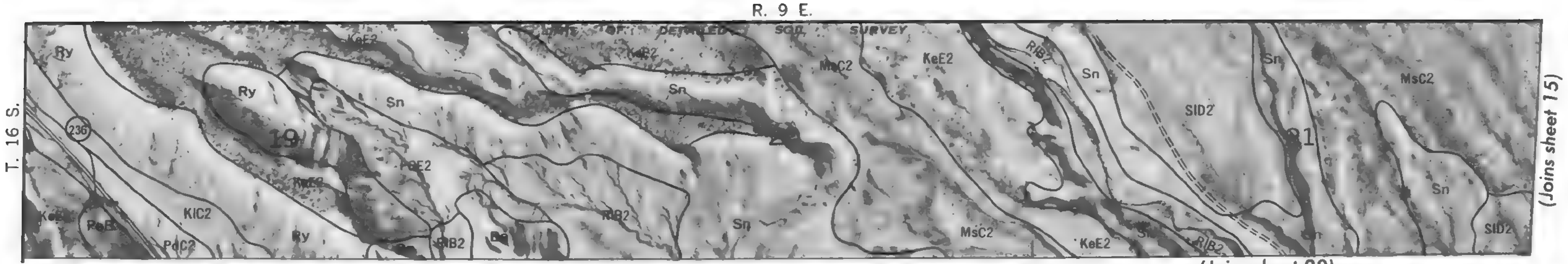
N

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 19

R. 9 E.

T. 16 S.

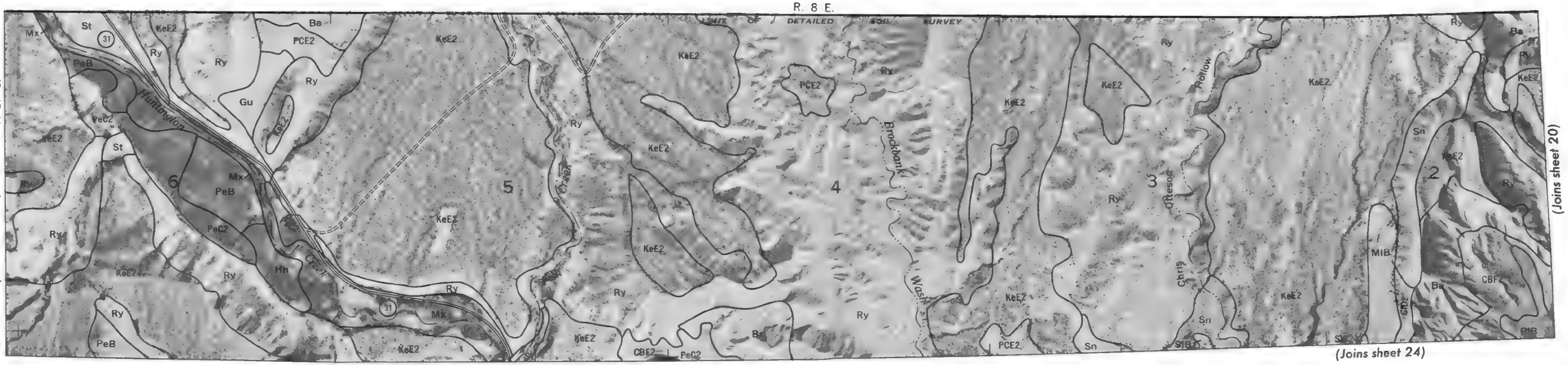



(Joins sheet 15)

(Joins sheet 20)

R. 8 E.

T. 17 S.




(Joins sheet 18)

(Joins sheet 20)

(Joins sheet 24)

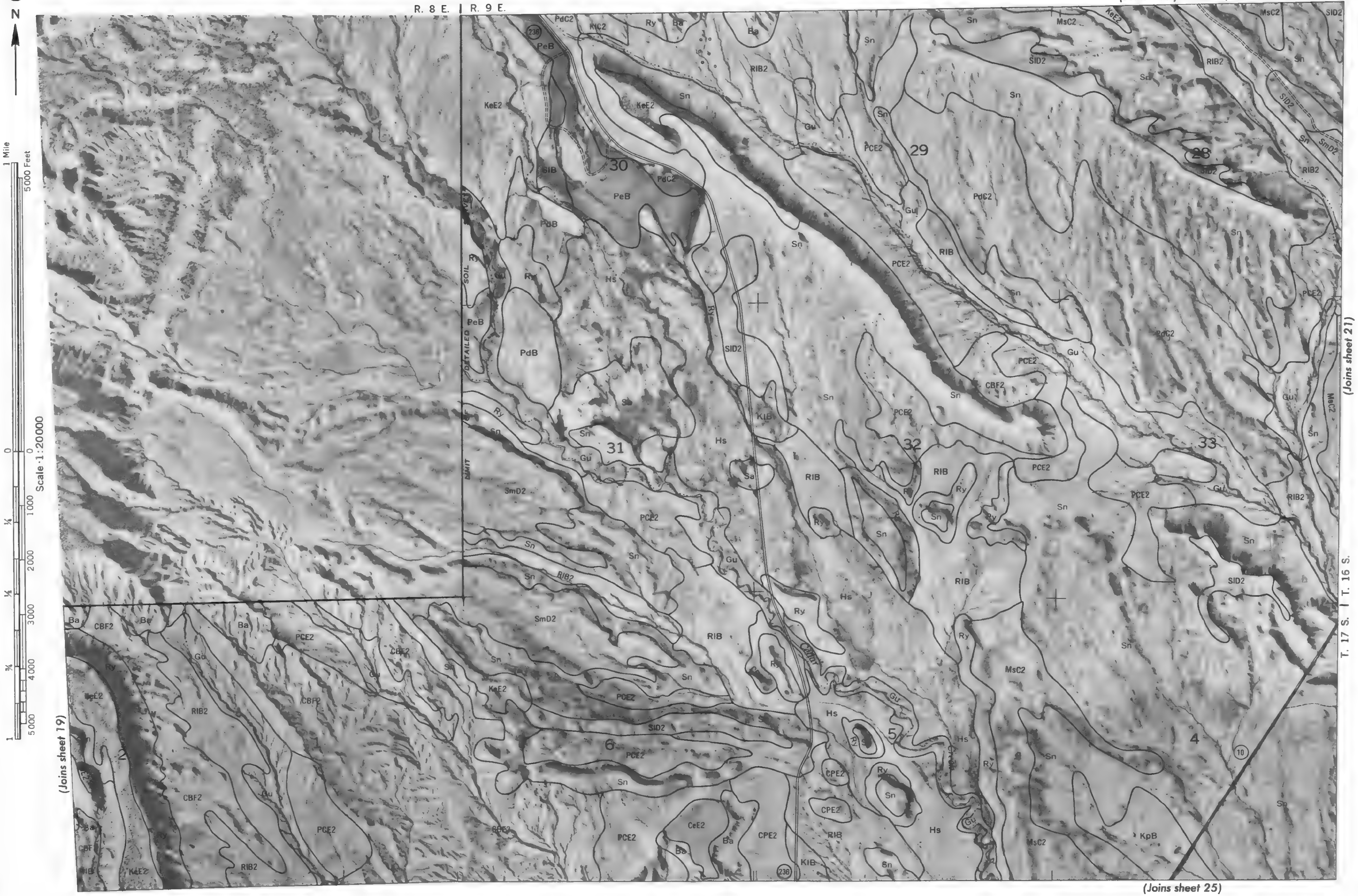
1 Mile

5000 Feet

0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000

Scale 1:20000




CARBON-EMERY AREA, UTAH NO. 20
Land division corners are approximately positioned on this map.
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.


This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.


CARBON-EMERY AREA, UTAH NO. 22

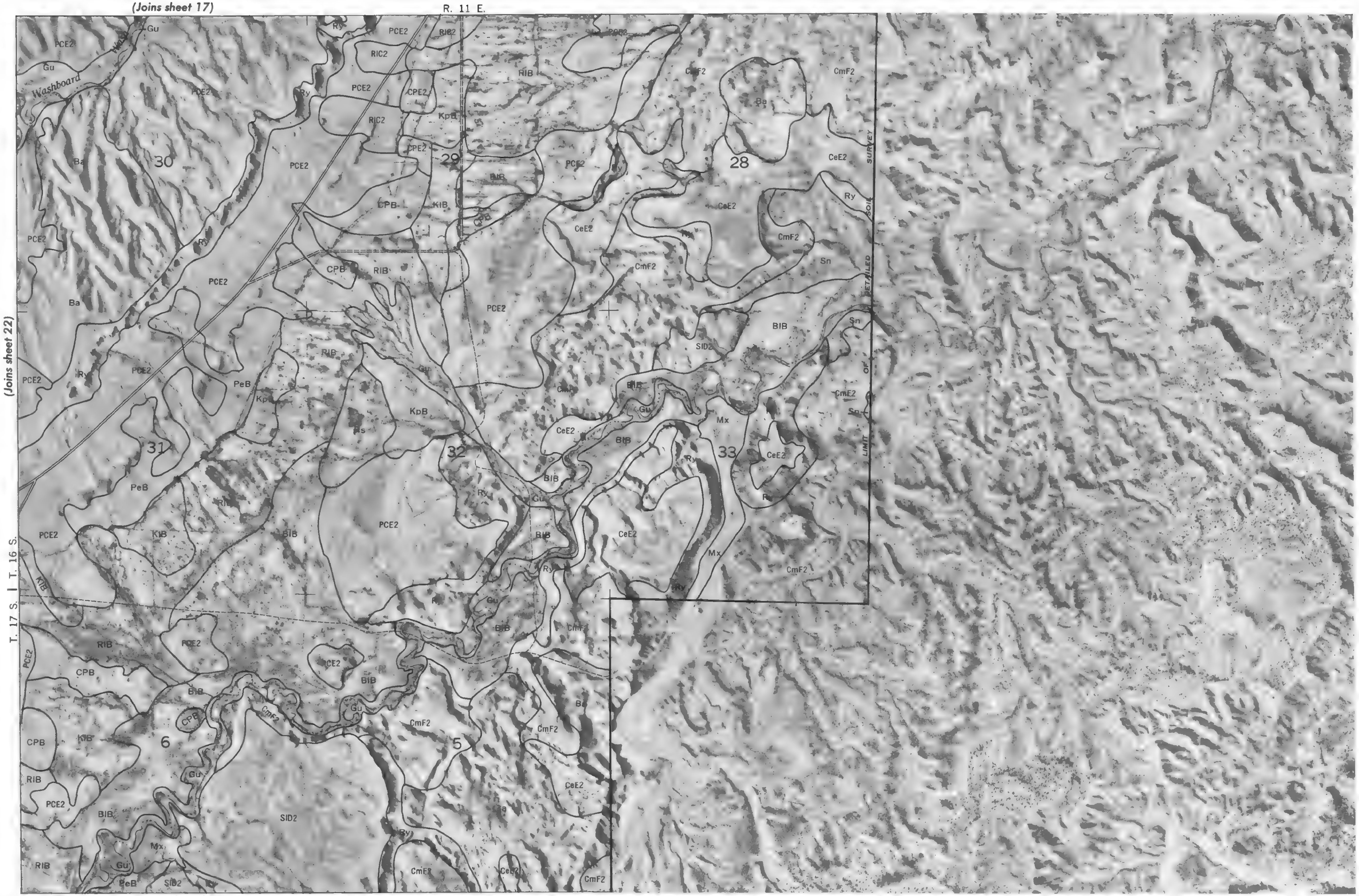
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

(Joins sheet 17)

R. 11 E.

(Joins sheet 22)




(Joins sheet 28)

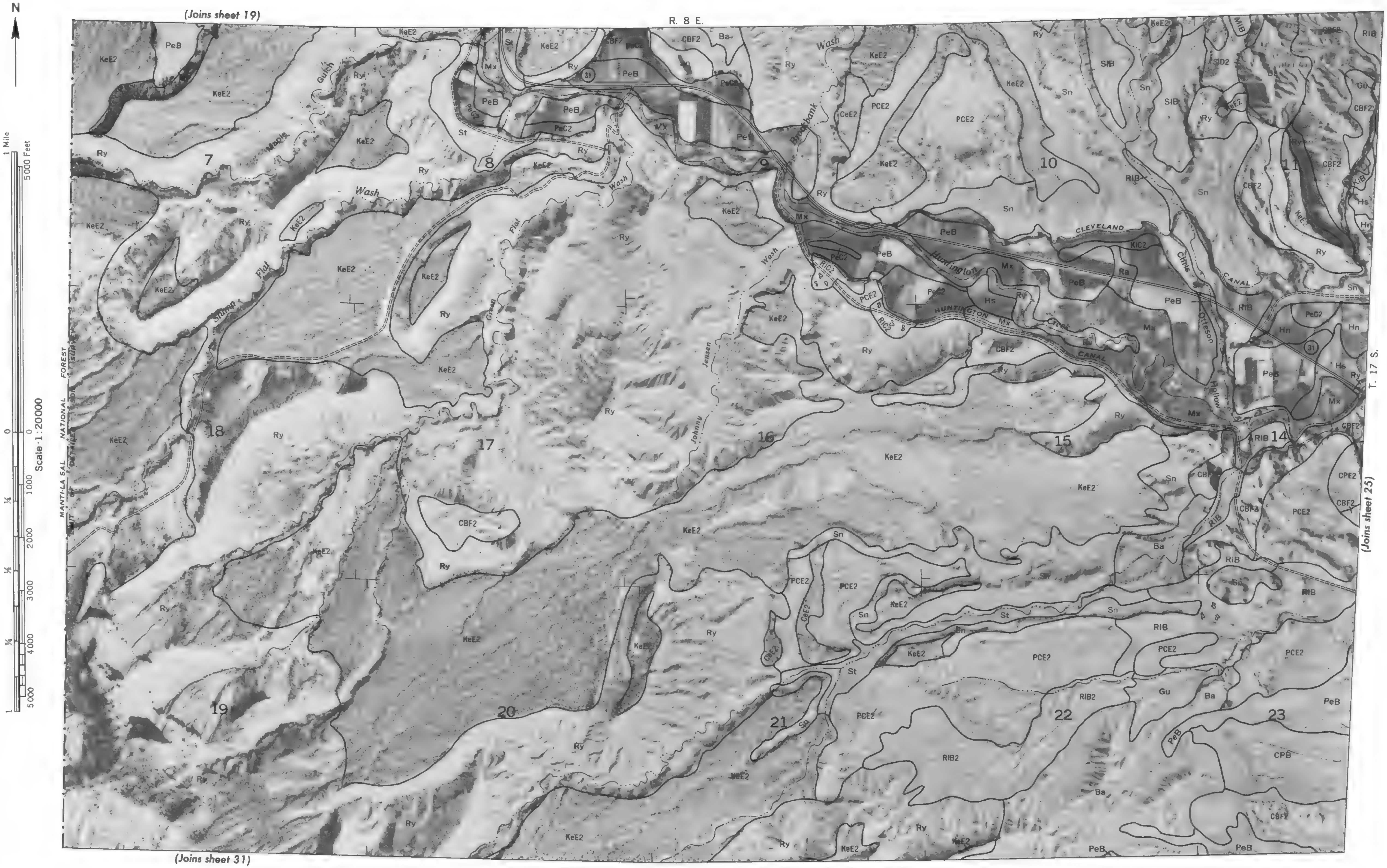
N

1 Mile
5000 Feet
0 ¼ ½ ¾ 1
0 1000 2000 3000 4000 5000
Scale 1:20000

CARBON-EMERY AREA, UTAH NO. 23

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




CARBON-EMERY AREA, UTAH NO. 24

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.


This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 25

CARBON-EMERY AREA, UTAH — SHEET NUMBER 26

N

(Joins sheet 21)

R. 9 E. | R. 10 E.


T. 17 S.

(Joins sheet 25)

(Joins sheet 27)

(Joins sheet 33)

Scale 1:20000

1 Mile

5000 Feet

0 1000 2000 3000 4000 5000

CARBON-EMERY AREA, UTAH NO. 26

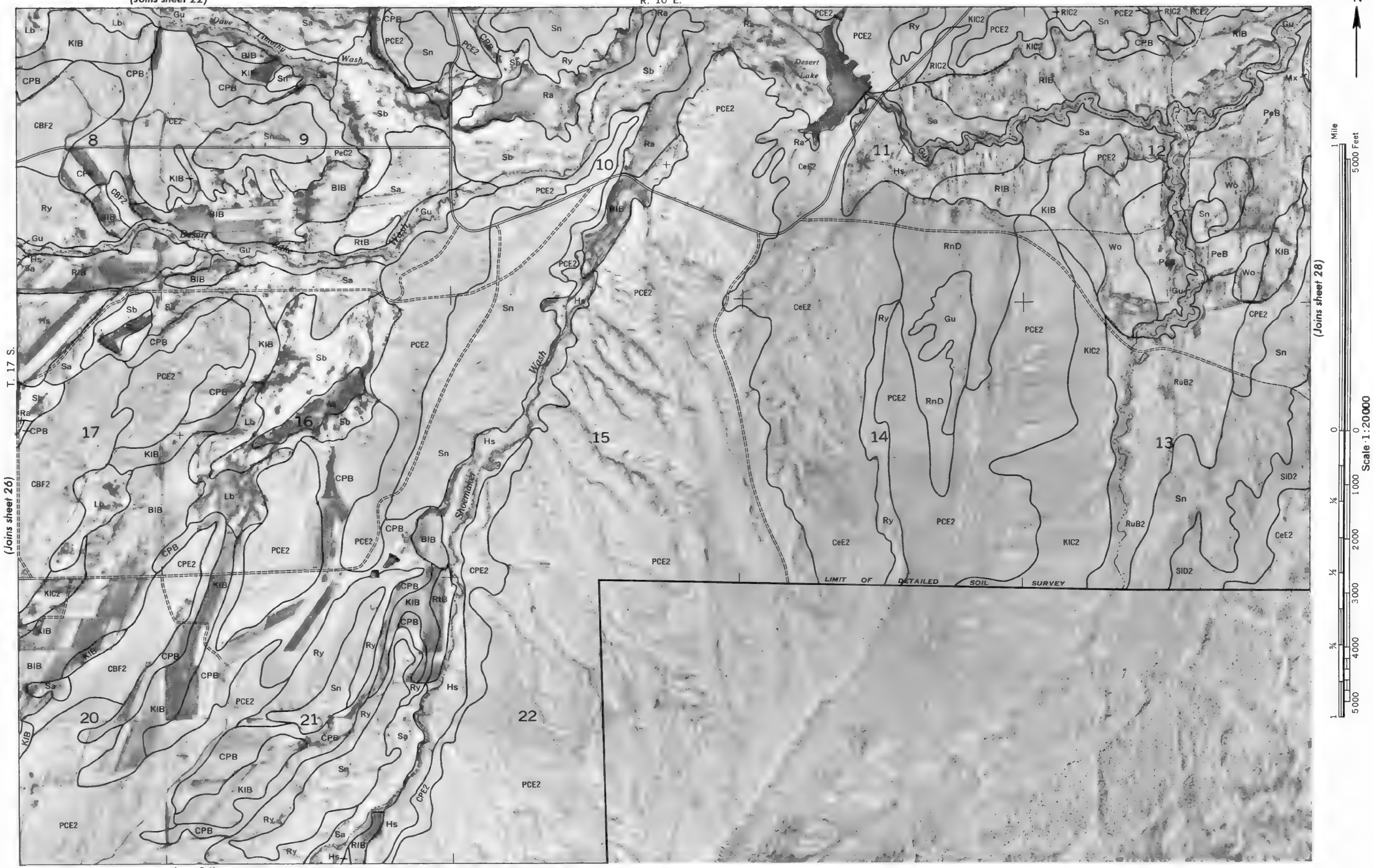
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

27

(Joins sheet 22)

R. 10 E.



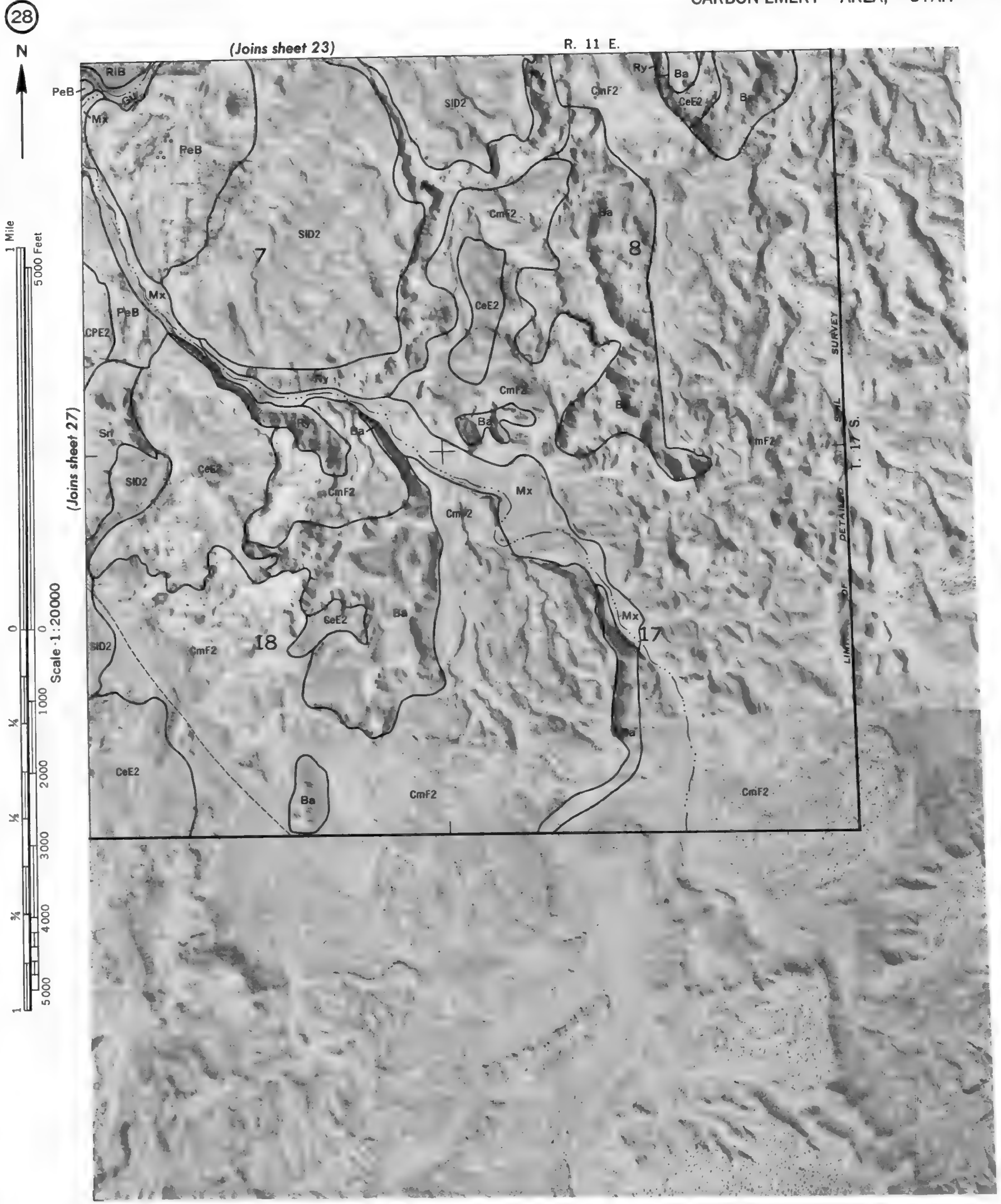

(Joins sheet 26)

(Joins sheet 28)

(Joins sheet 34)

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 27




CARBON-EMERY AREA, UTAH NO. 28

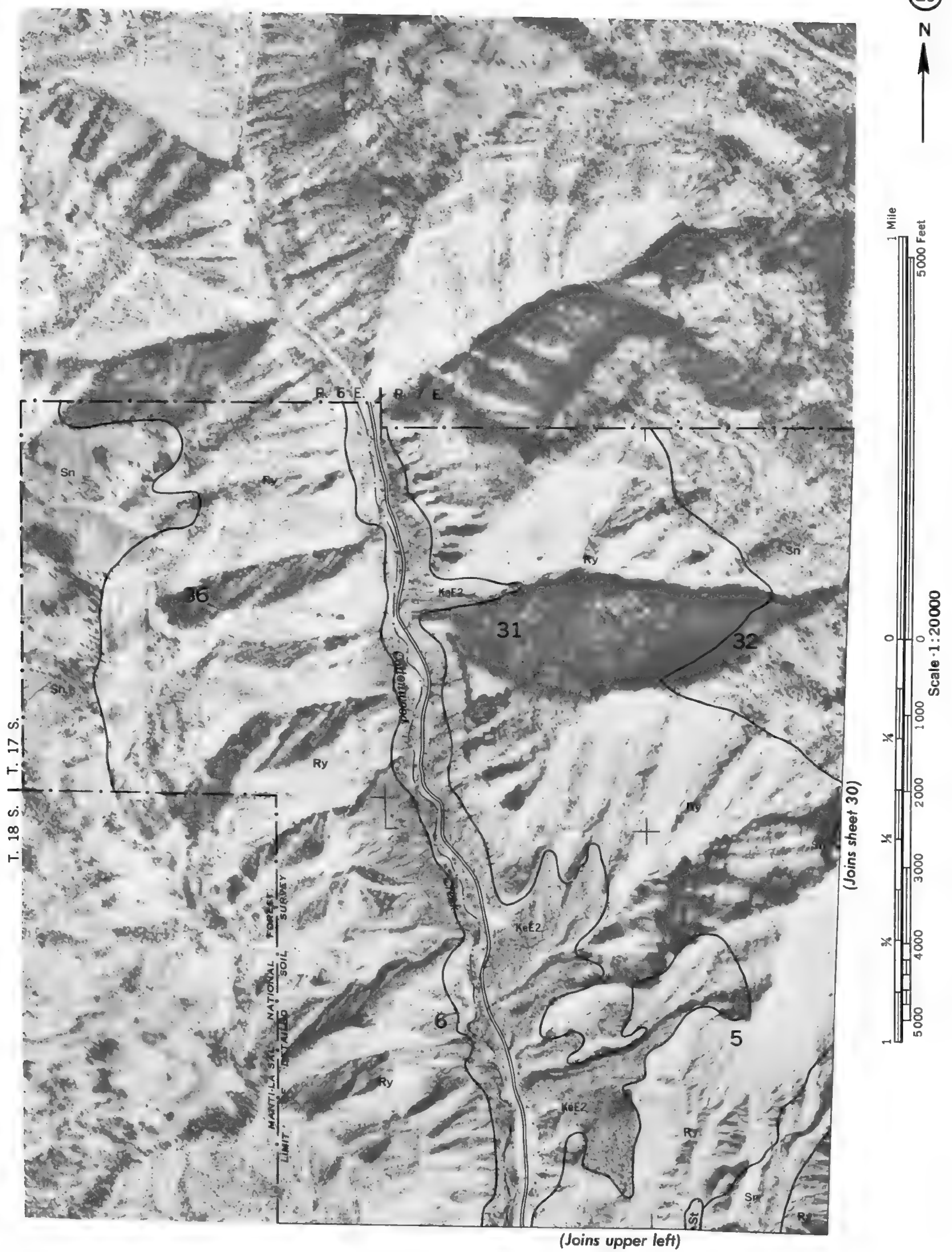
Land division corners are approximately positioned on this map.

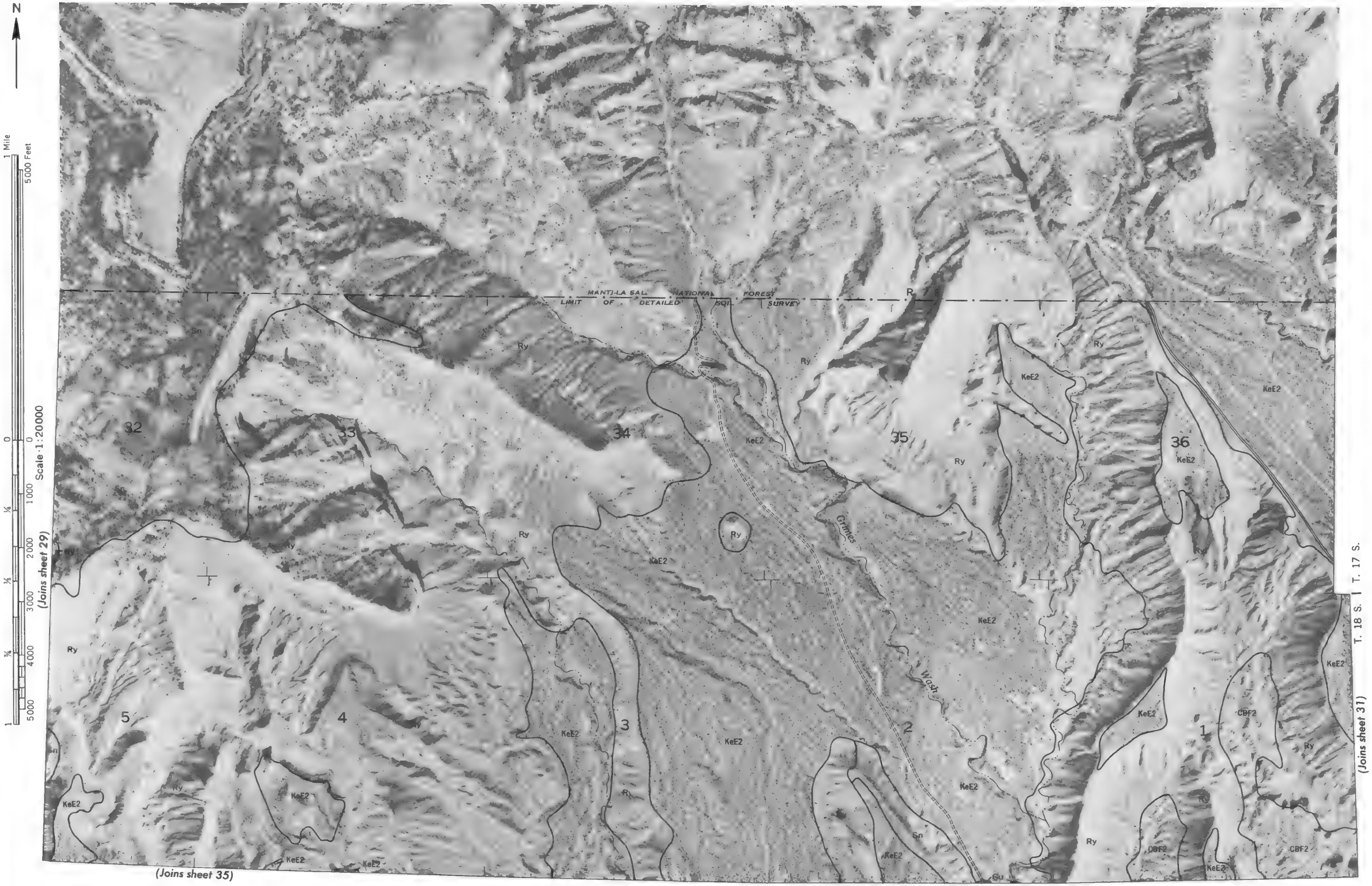
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 29

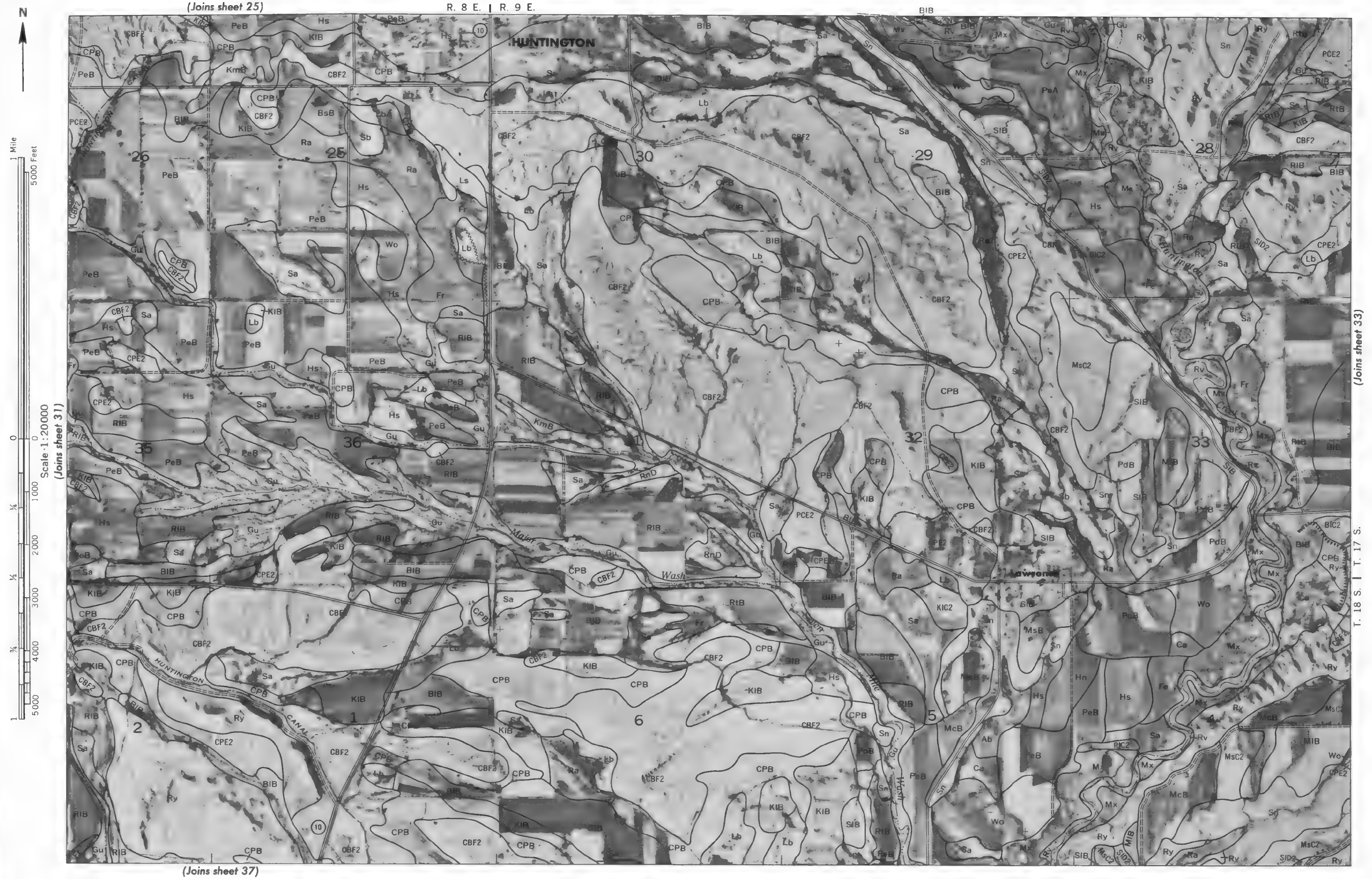



CARBON-EMERY AREA, UTAH NO. 30
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

(31)


This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.



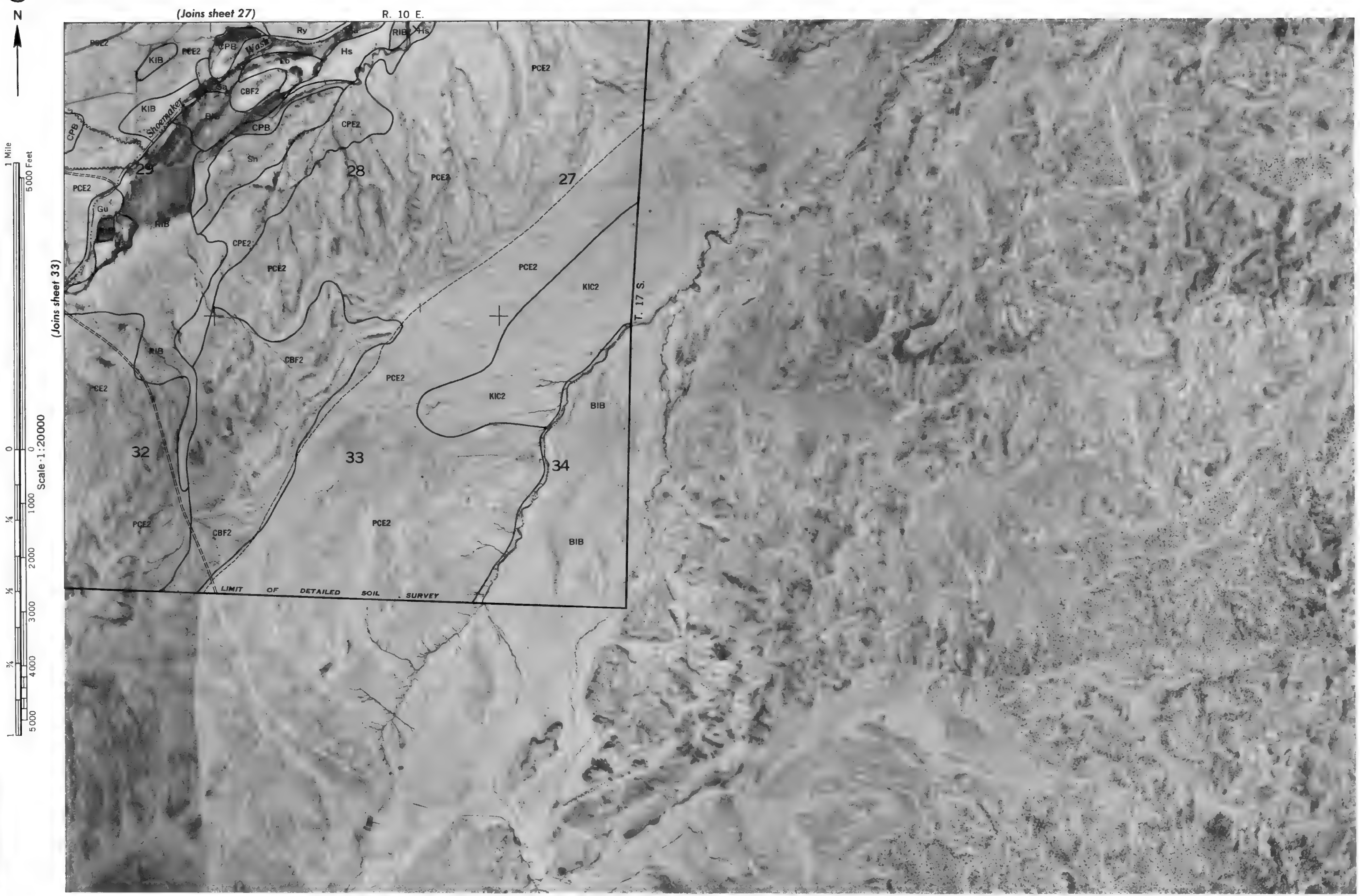

CARBON-EMERY AREA, UTAH NO. 32

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.


This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.
CARBON-EMERY AREA, UTAH NO. 33

CARBON-EMERY AREA, UTAH — SHEET NUMBER 34




CARBON-EMERY AREA, UTAH NO. 34

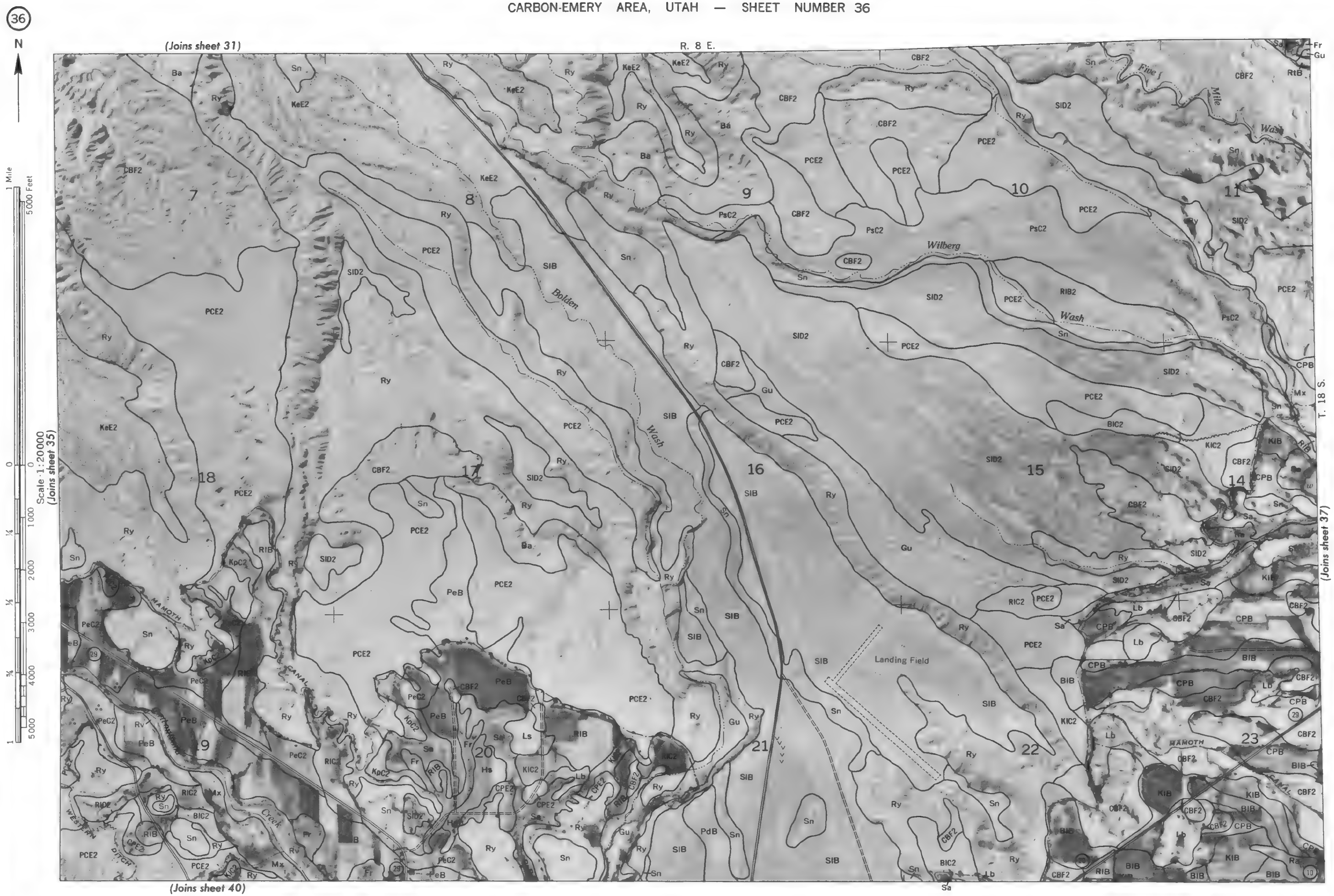
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.


This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 35




CARBON-EMERY AREA, UTAH NO. 36
Land division corners are approximately positioned on this map.

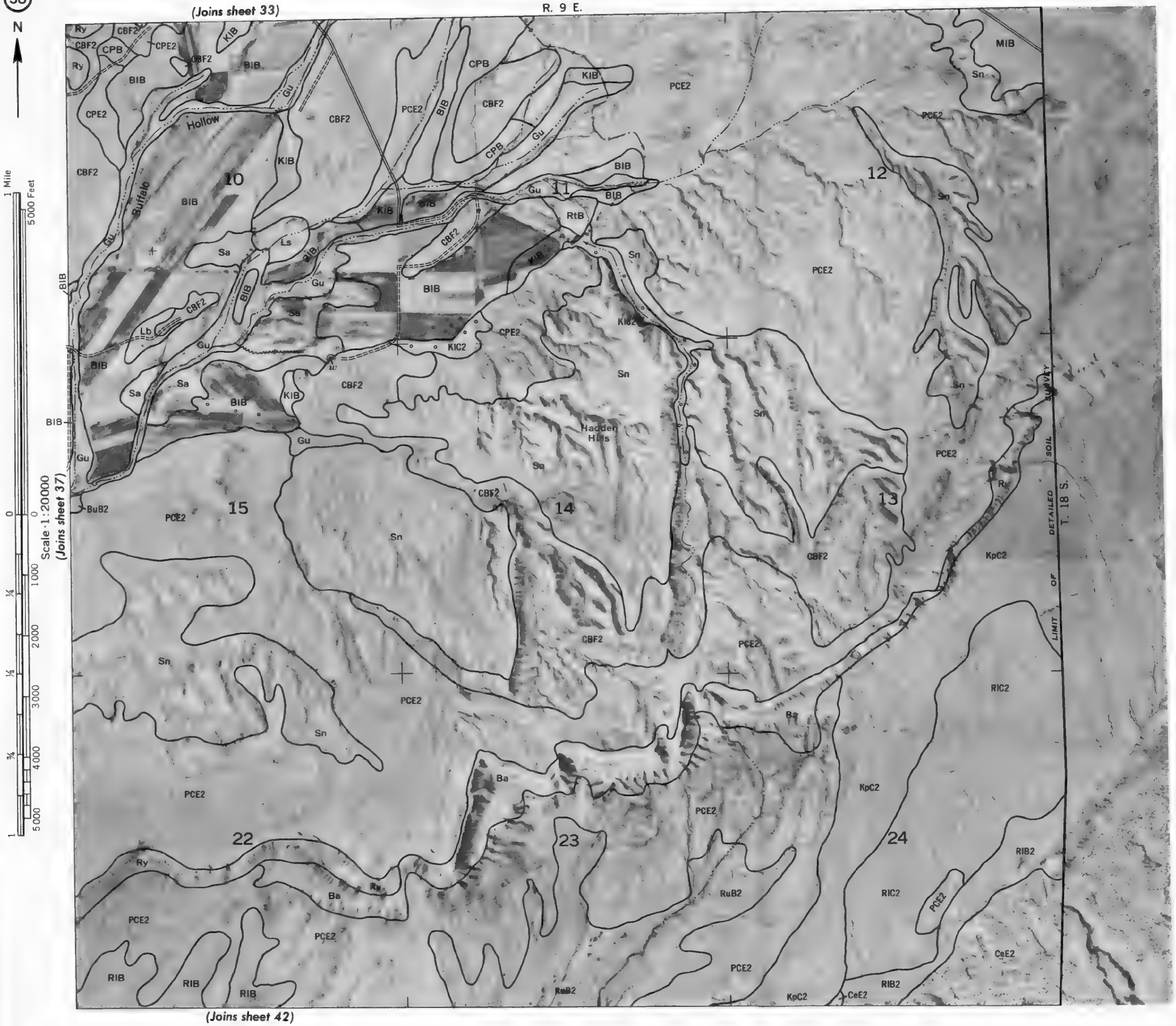
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

37


This map is one of a set compiled in 196[illegible] as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 37

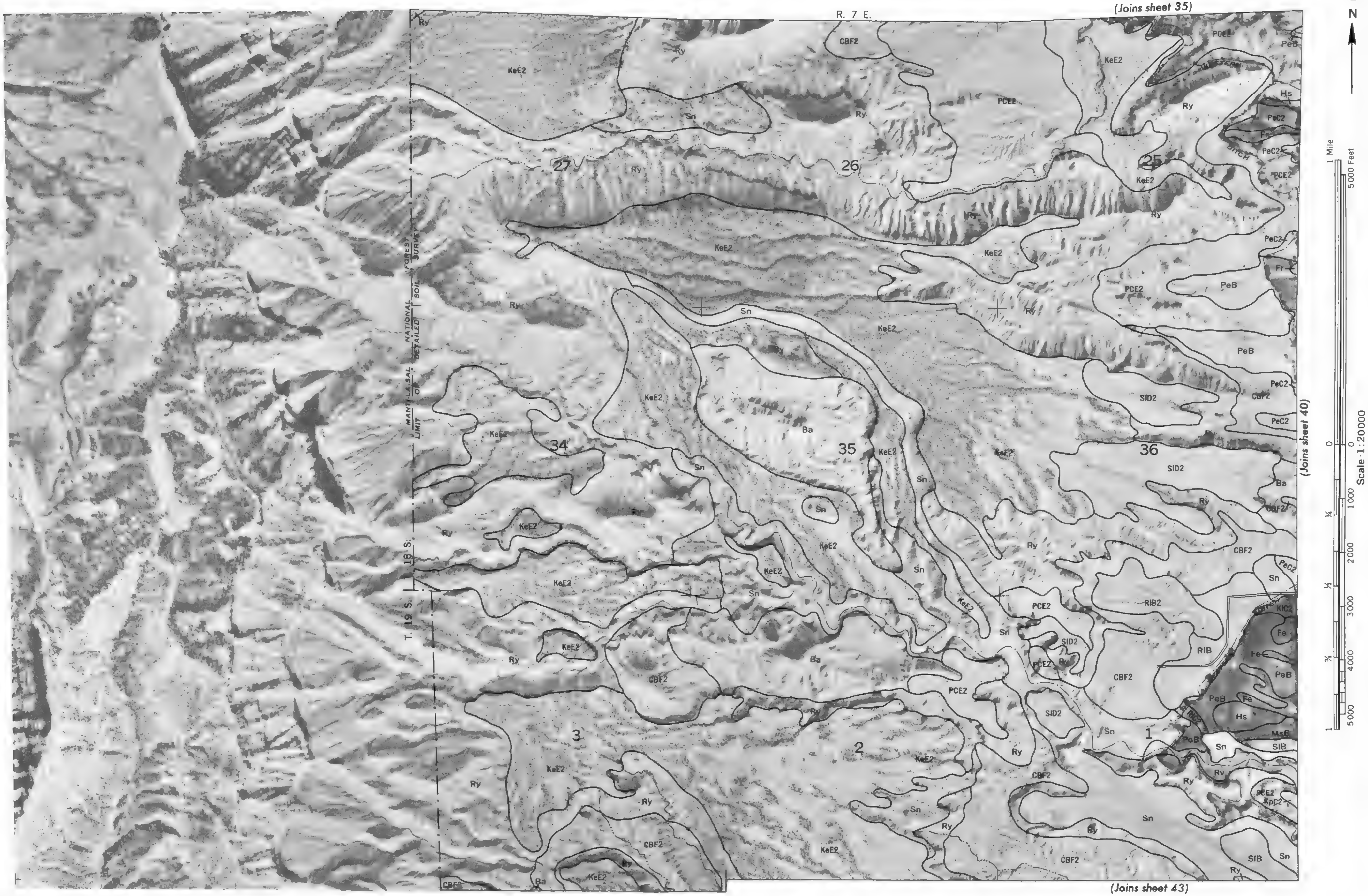
CARBON-EMERY AREA, UTAH — SHEET NUMBER 38




CARBON-EMERY AREA, UTAH NO. 38

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 39

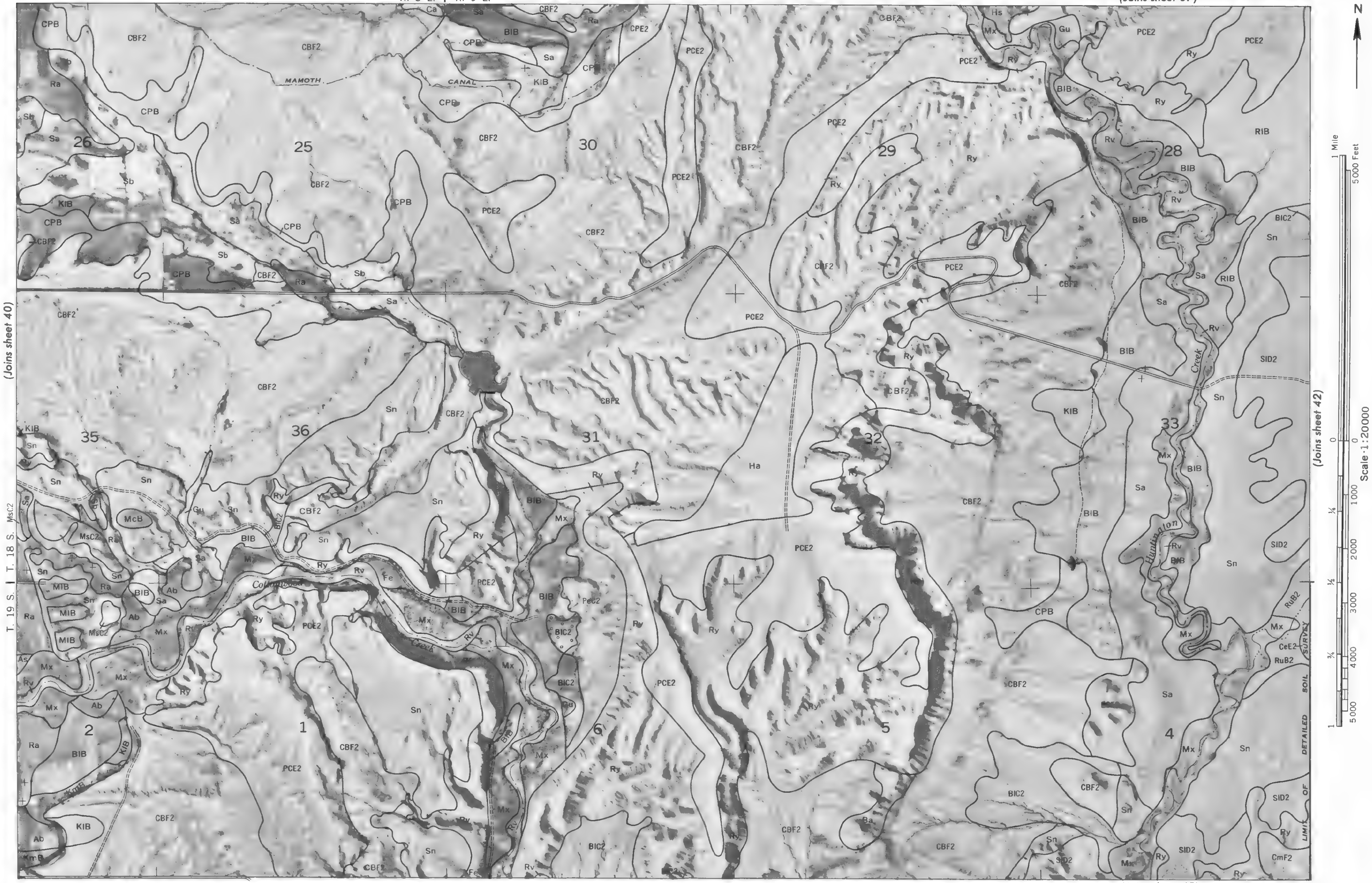

CARBON-EMERY AREA, UTAH NO. 40

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

(Joins sheet 37)

R. 8 E. | R. 9 E.




(Joins sheet 40)

(Joins sheet 42)

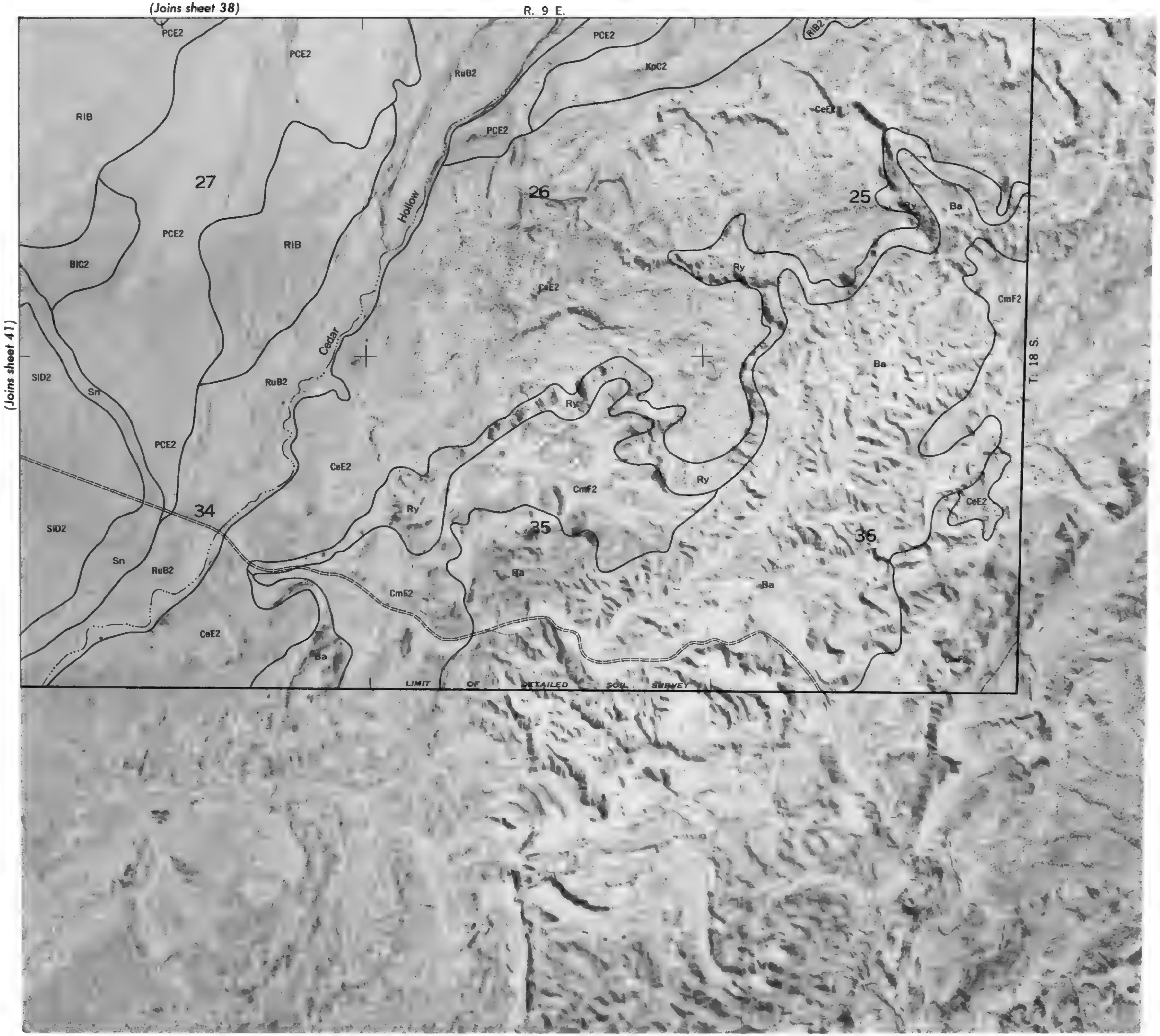
(Joins sheet 45)

T. 18 S. | T. 19 S.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 41

CARBON-EMERY AREA, UTAH — SHEET NUMBER 42





CARBON-EMERY AREA, UTAH NO. 42

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.


This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

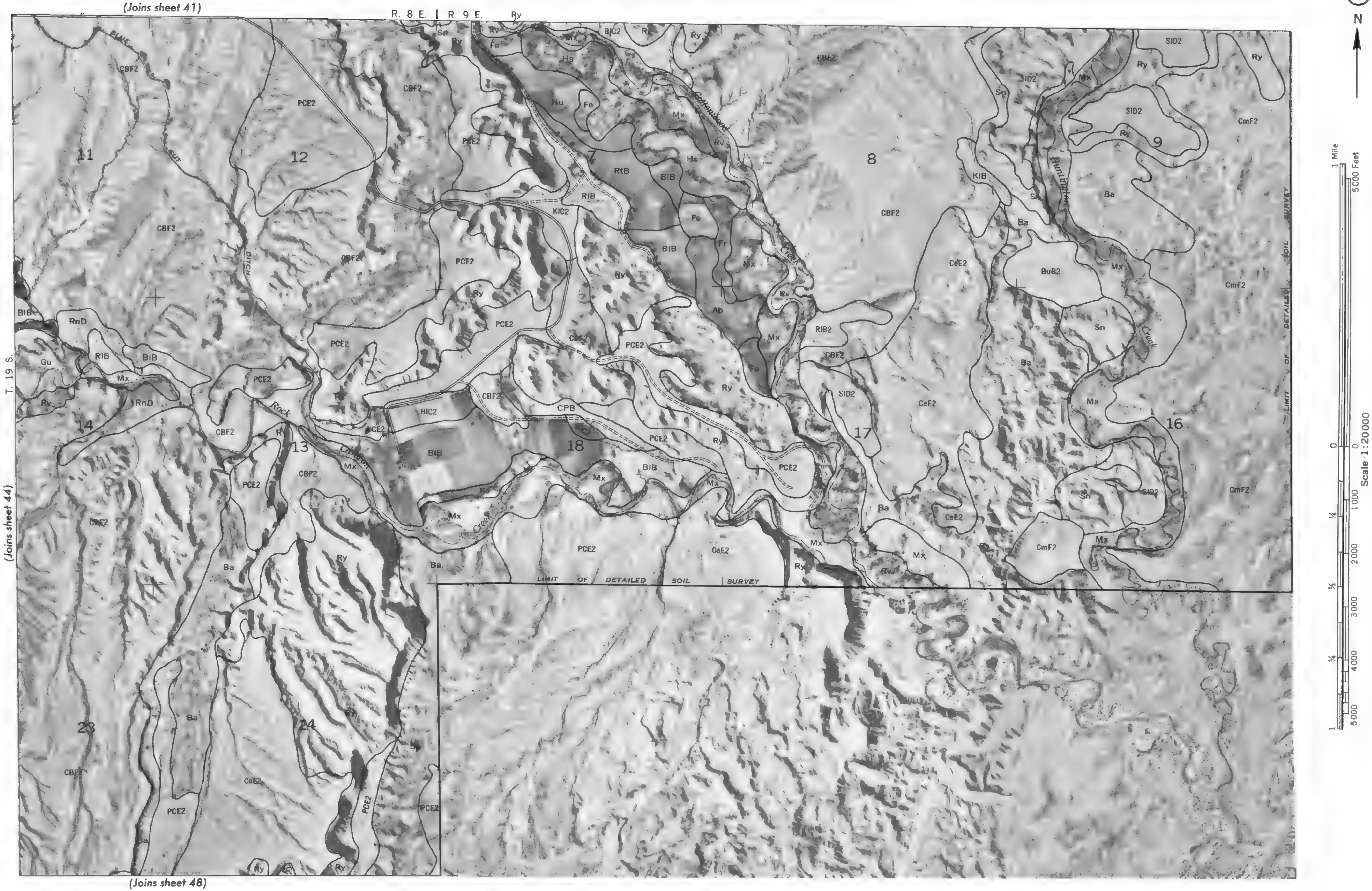
CARBON-EMERY AREA, UTAH NO. 43


CARBON-EMERY AREA, UTAH NO. 44

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and United States Department of the Interior, Bureau of Land Management.

(45)




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 45

CARBON-EMERY AREA, UTAH — SHEET NUMBER 46

N

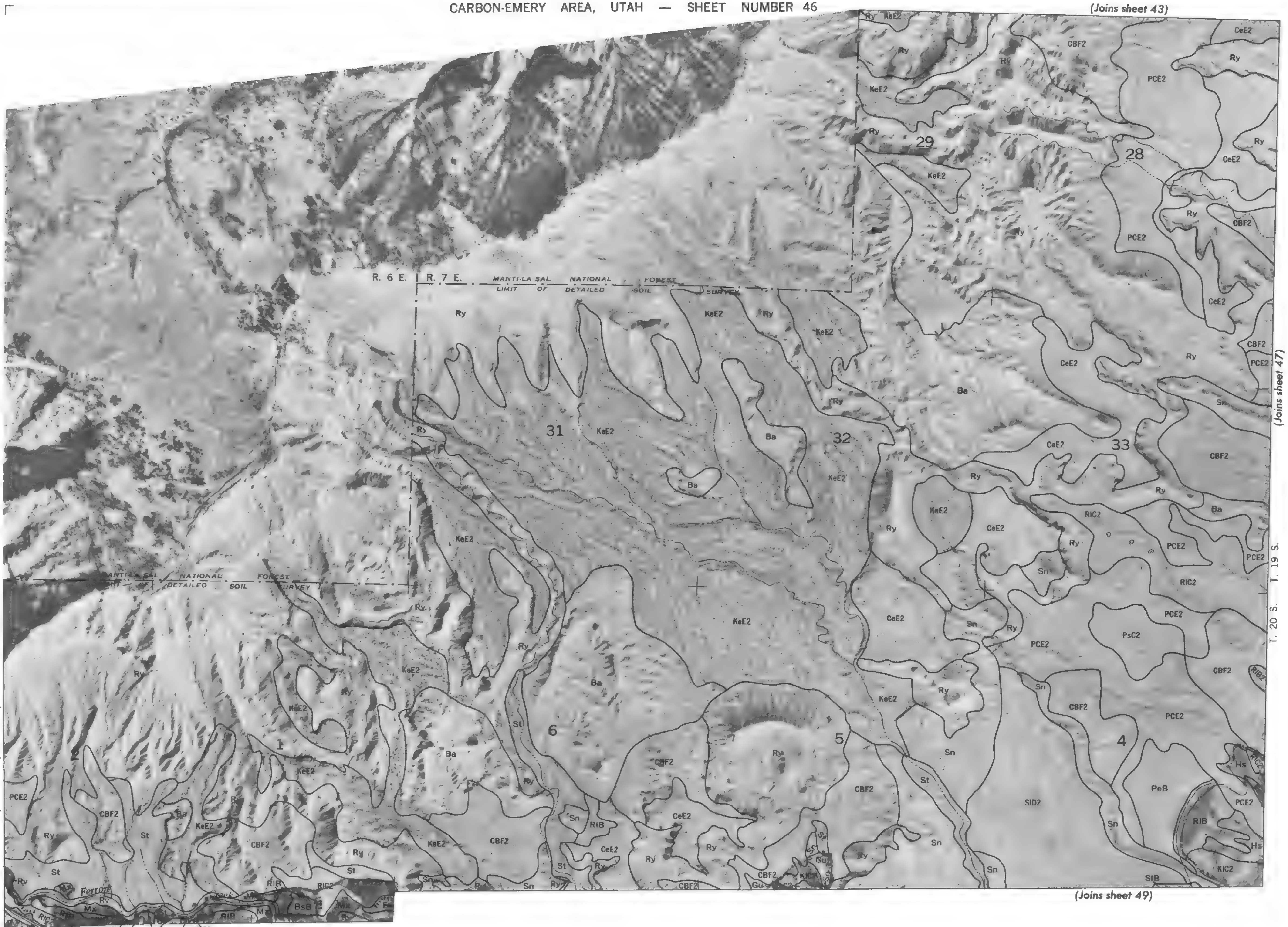
1 Mile
5000 Feet

Scale 1:20000

0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000

(Joins sheet 43)




(Joins sheet 47)

(Joins sheet 49)

(Joins inset, sheet 52)

CARBON-EMERY AREA, UTAH NO. 46
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.


This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

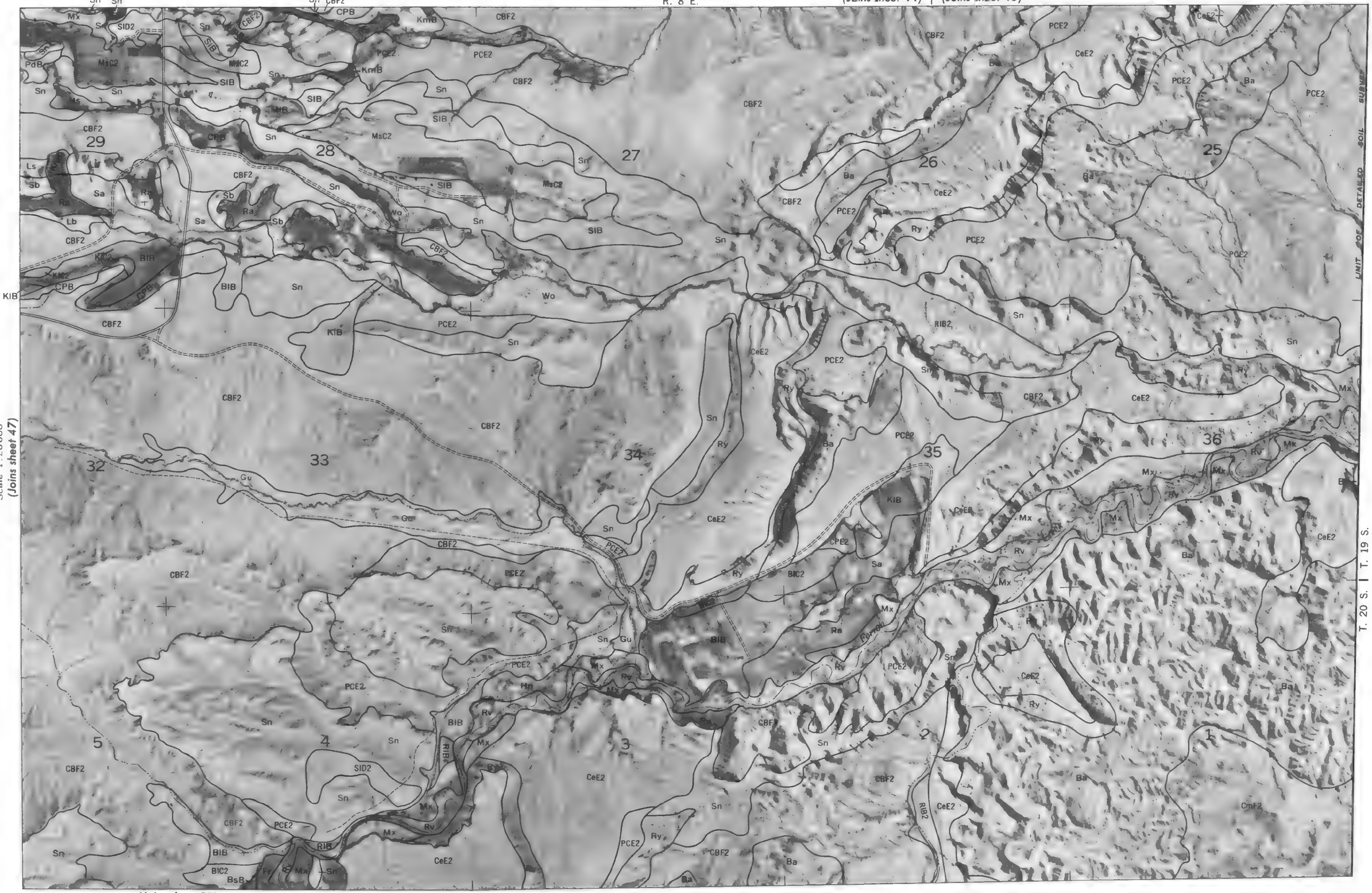
CARBON-EMERY AREA, UTAH NO. 47

# CARBON-EMERY AREA, UTAH — SHEET NUMBER 48

R. 8 E.

(Joins sheet 44) | (Joins sheet 45)

N




(Joins sheet 47)

(Joins sheet 51)

Scale 1:20000

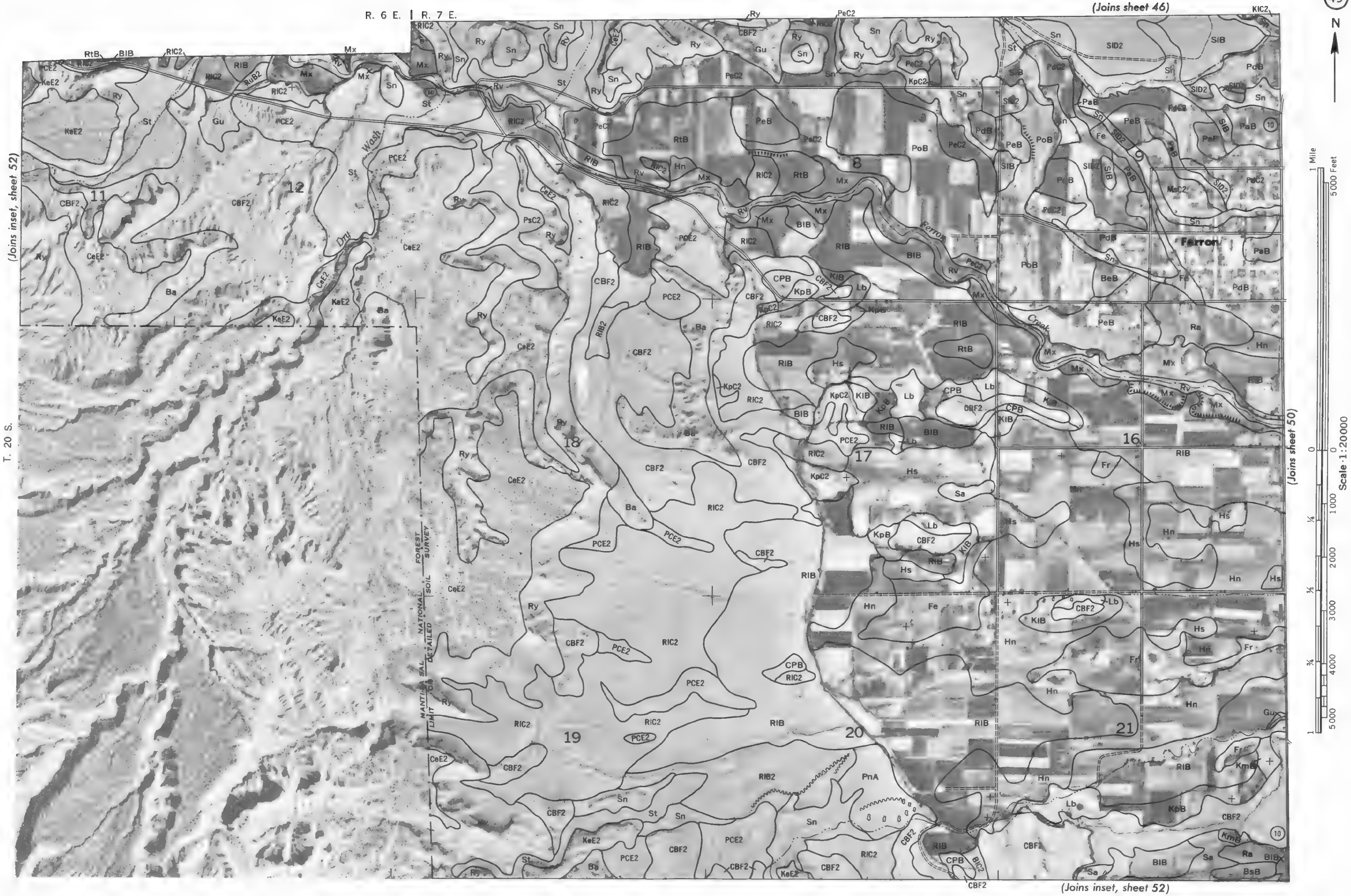
1 Mile — ¾ — ½ — ¼ — 0

5000 Feet — 4000 — 3000 — 2000 — 1000 — 0

CARBON-EMERY AREA, UTAH NO. 48

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

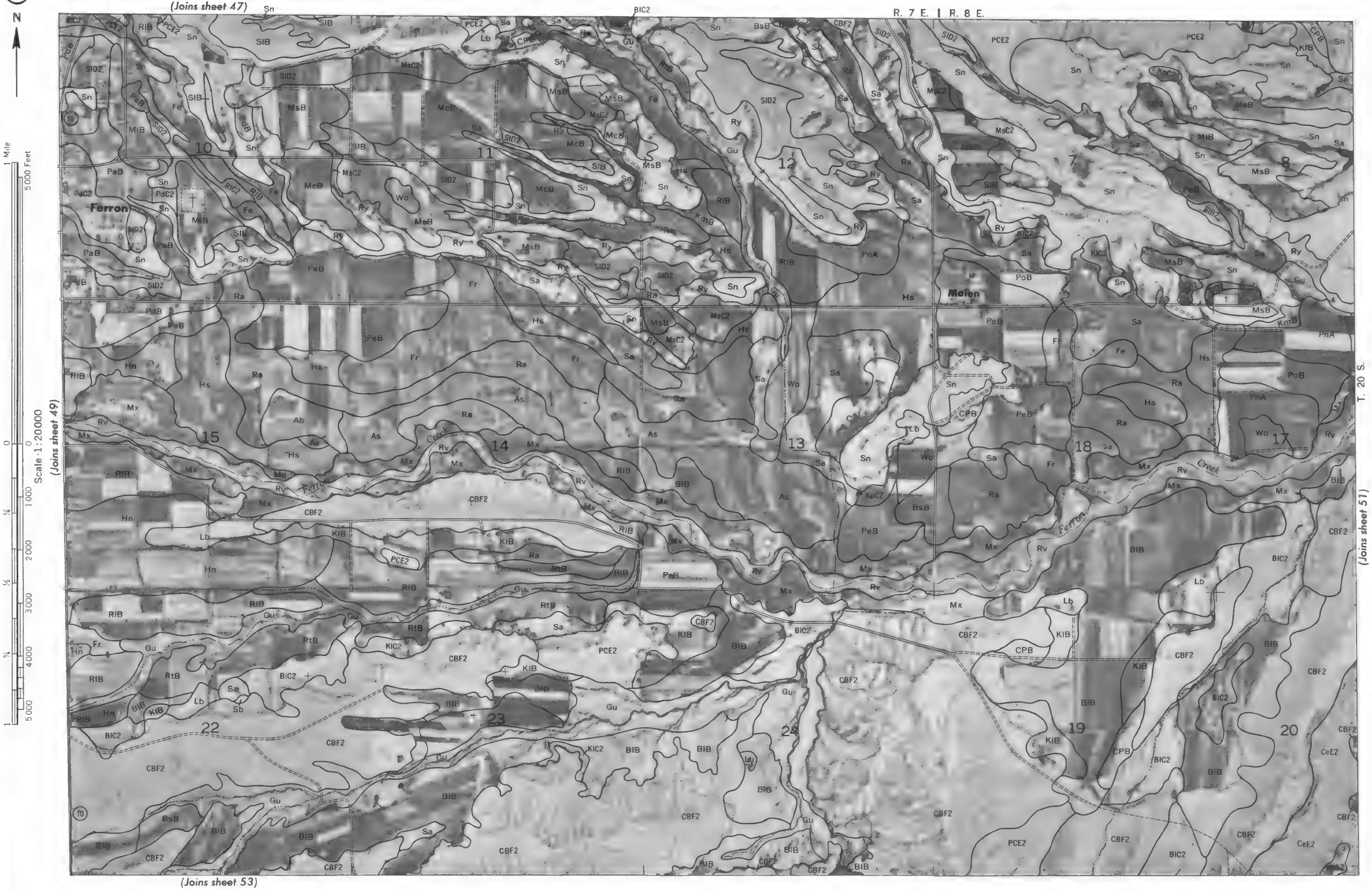



This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 49

CARBON-EMERY AREA, UTAH — SHEET NUMBER 50



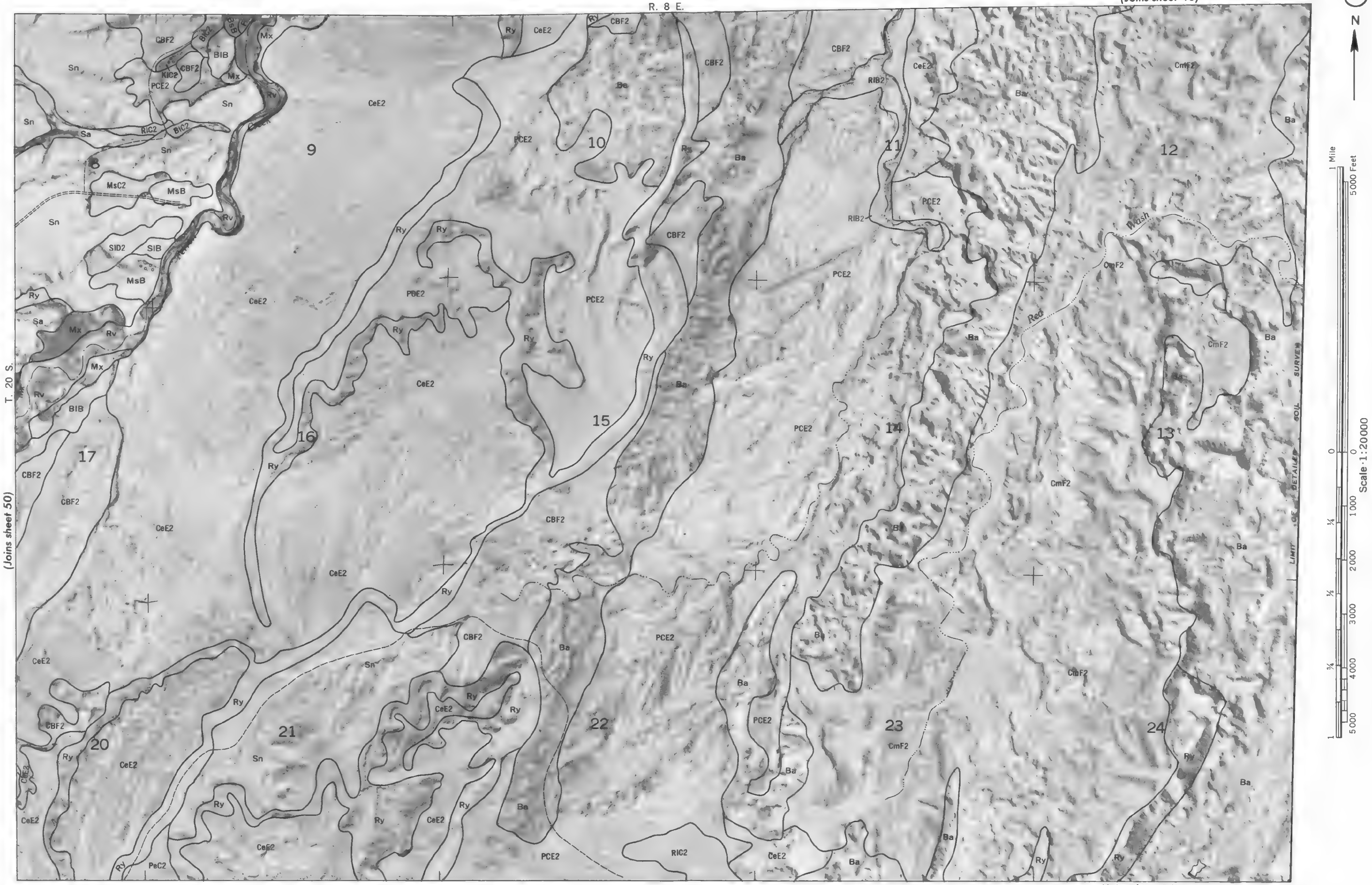

CARBON-EMERY AREA, UTAH NO. 50

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

(51)

(Joins sheet 48)




(Joins sheet 50)

(Joins sheet 54)

CARBON-EMERY AREA, UTAH NO. 51

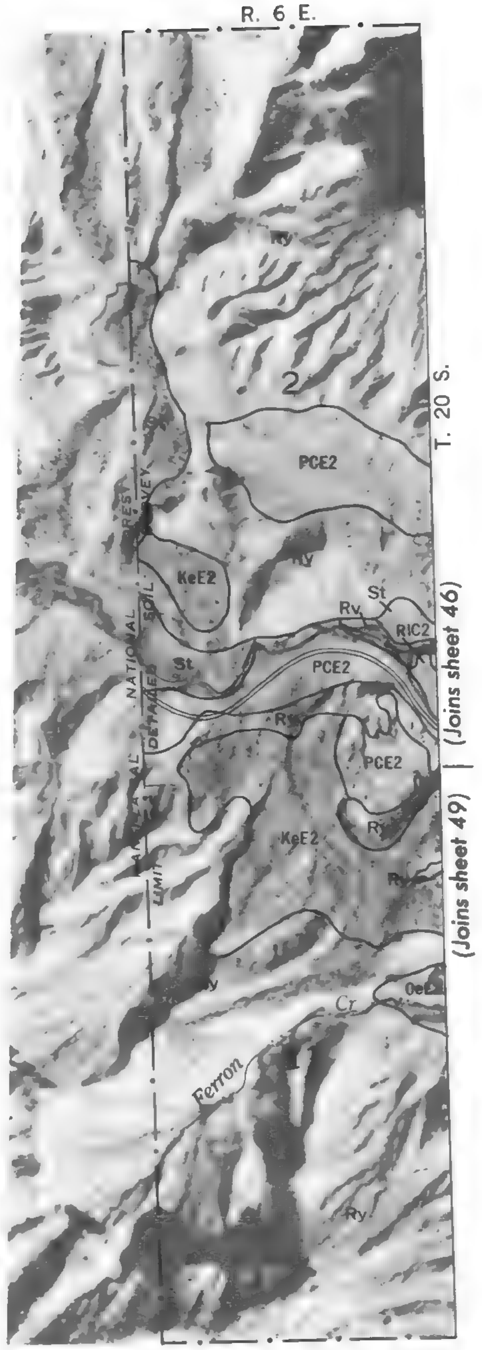
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

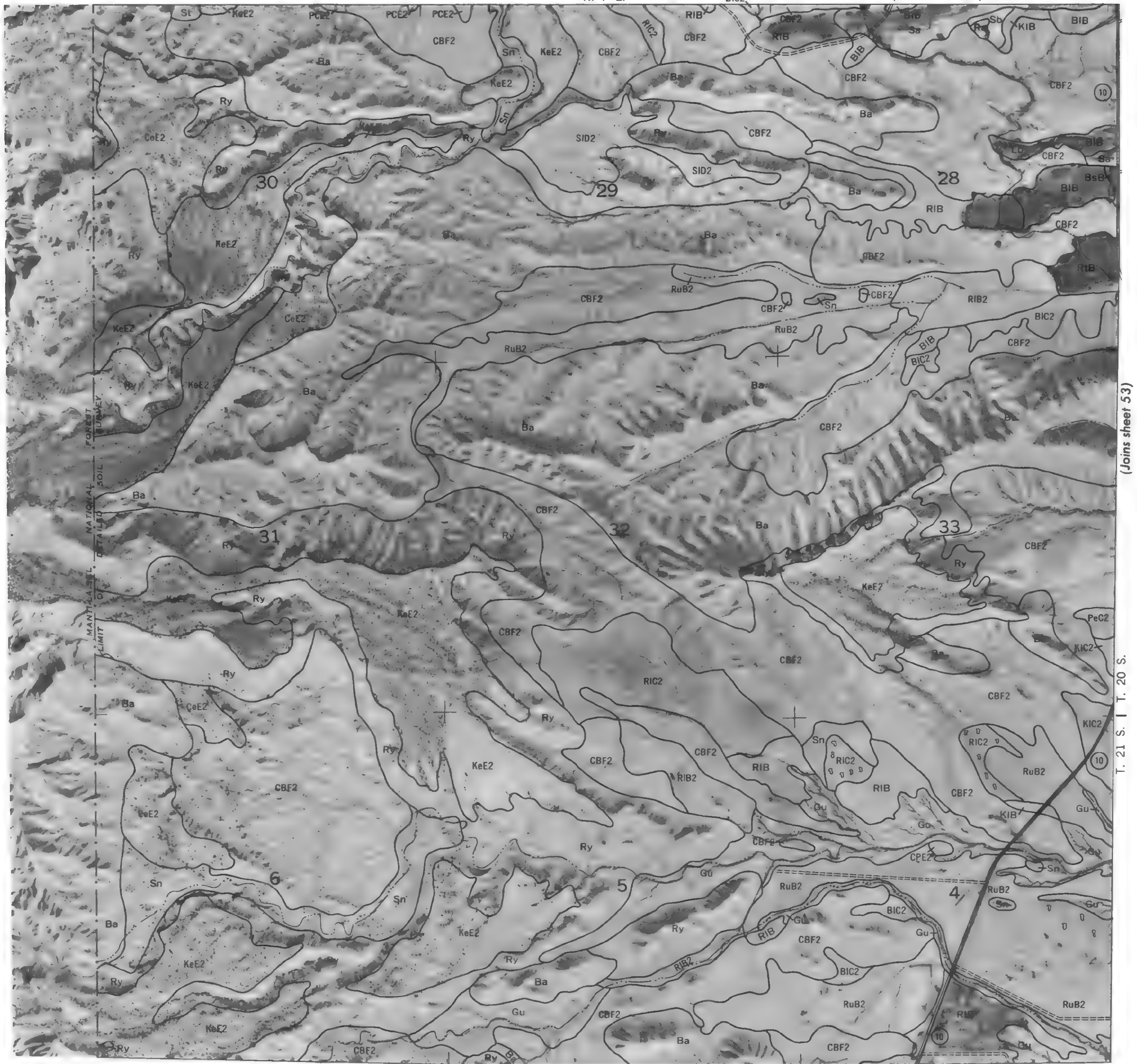
N

Scale 1:20000

1 Mile ¾ ½ ¼ 0

5000 Feet 4000 3000 2000 1000 0 5000

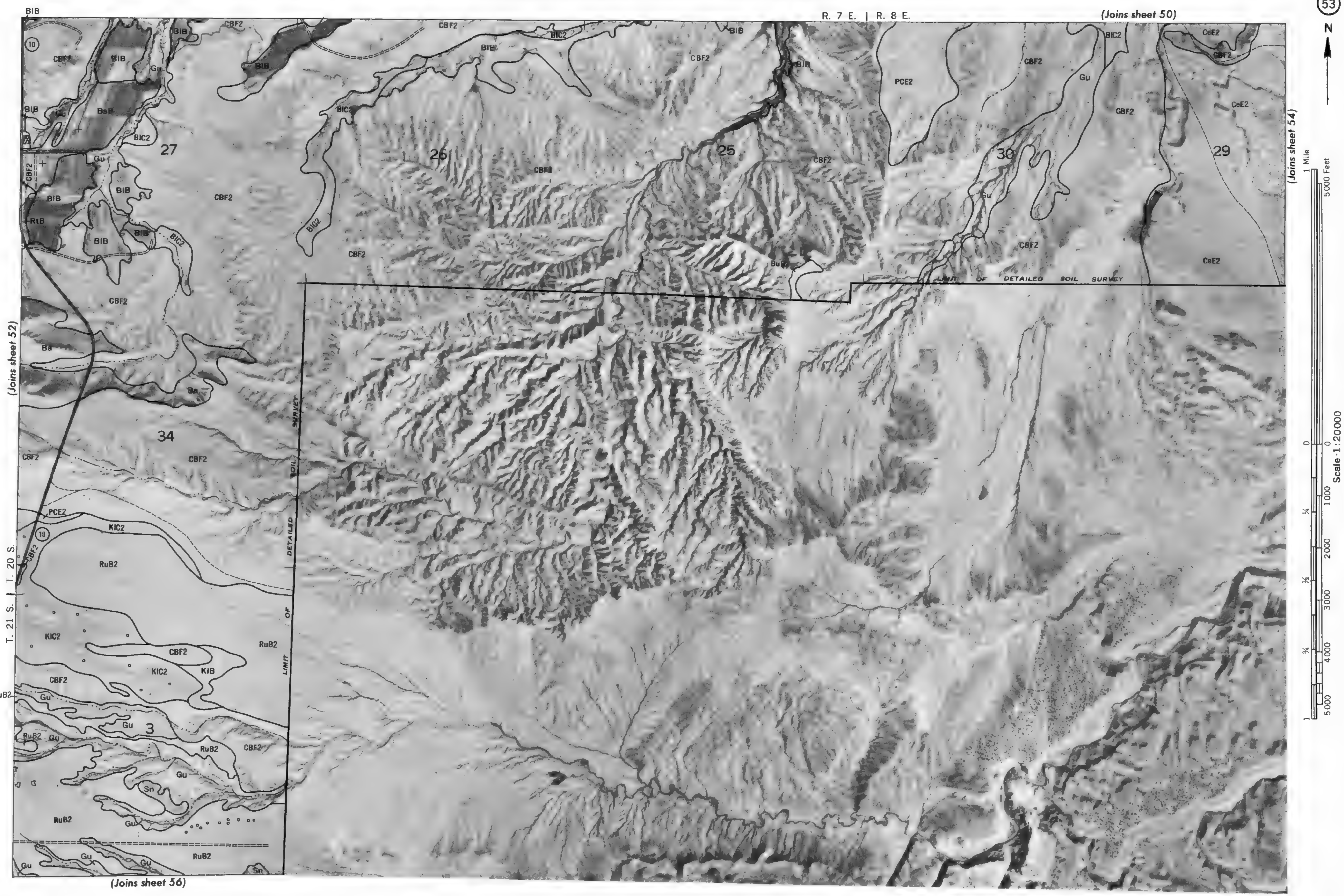



CARBON-EMERY AREA, UTAH NO. 52

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

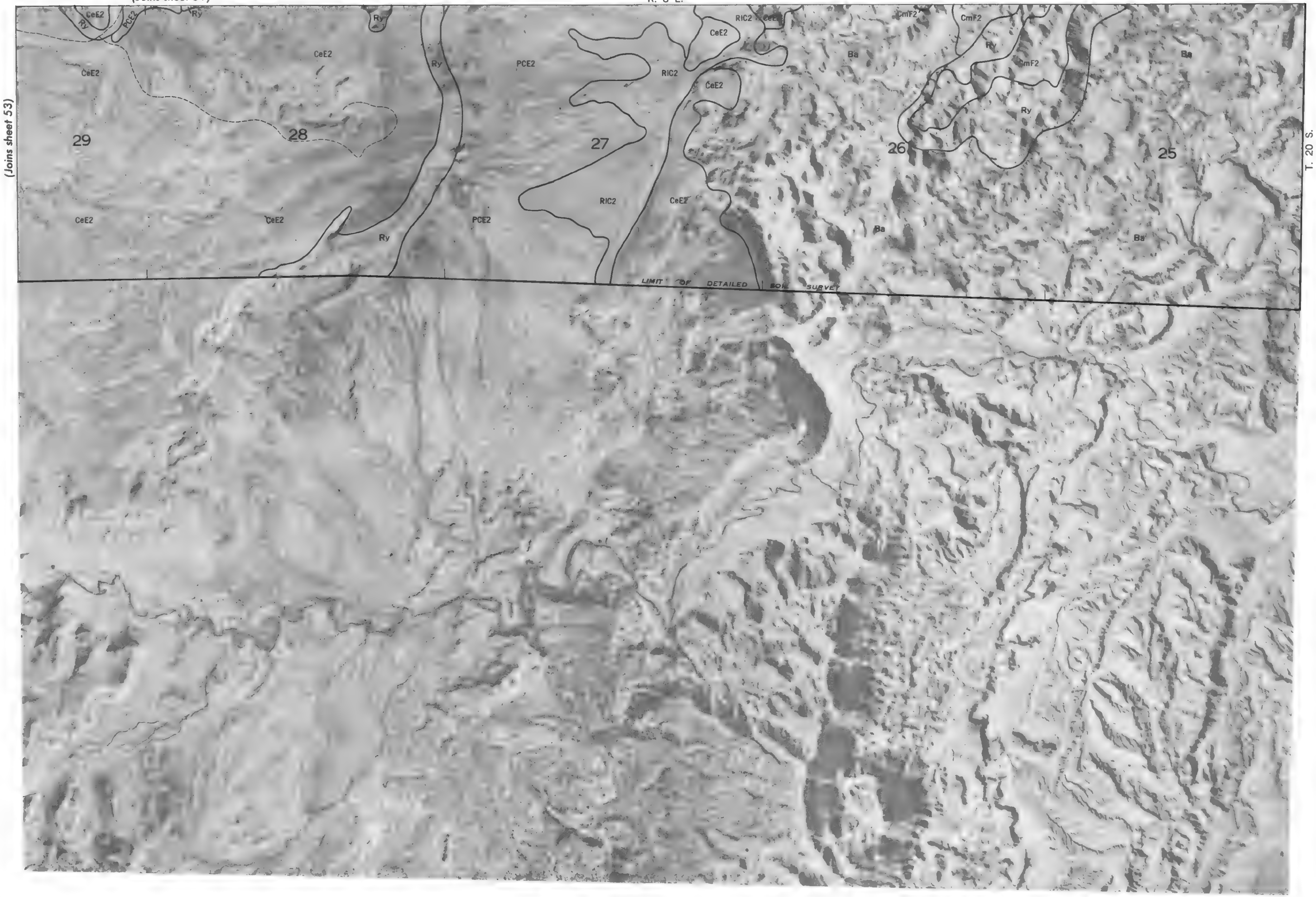



This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 53

CARBON-EMERY AREA, UTAH — SHEET NUMBER 54




N

Scale 1:20000

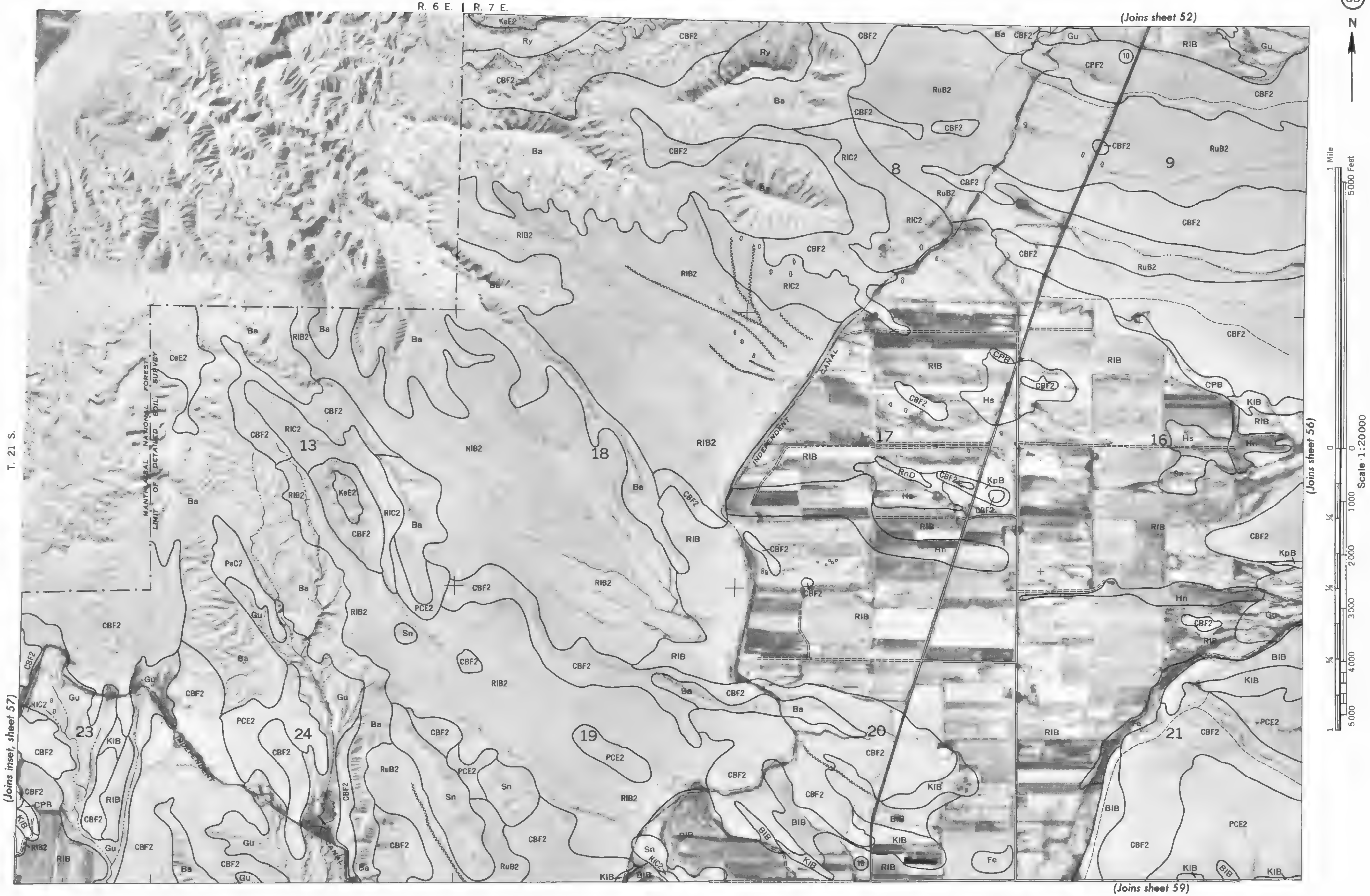
1 Mile ¾ ½ ¼ 0

5000 Feet 4000 3000 2000 1000 0

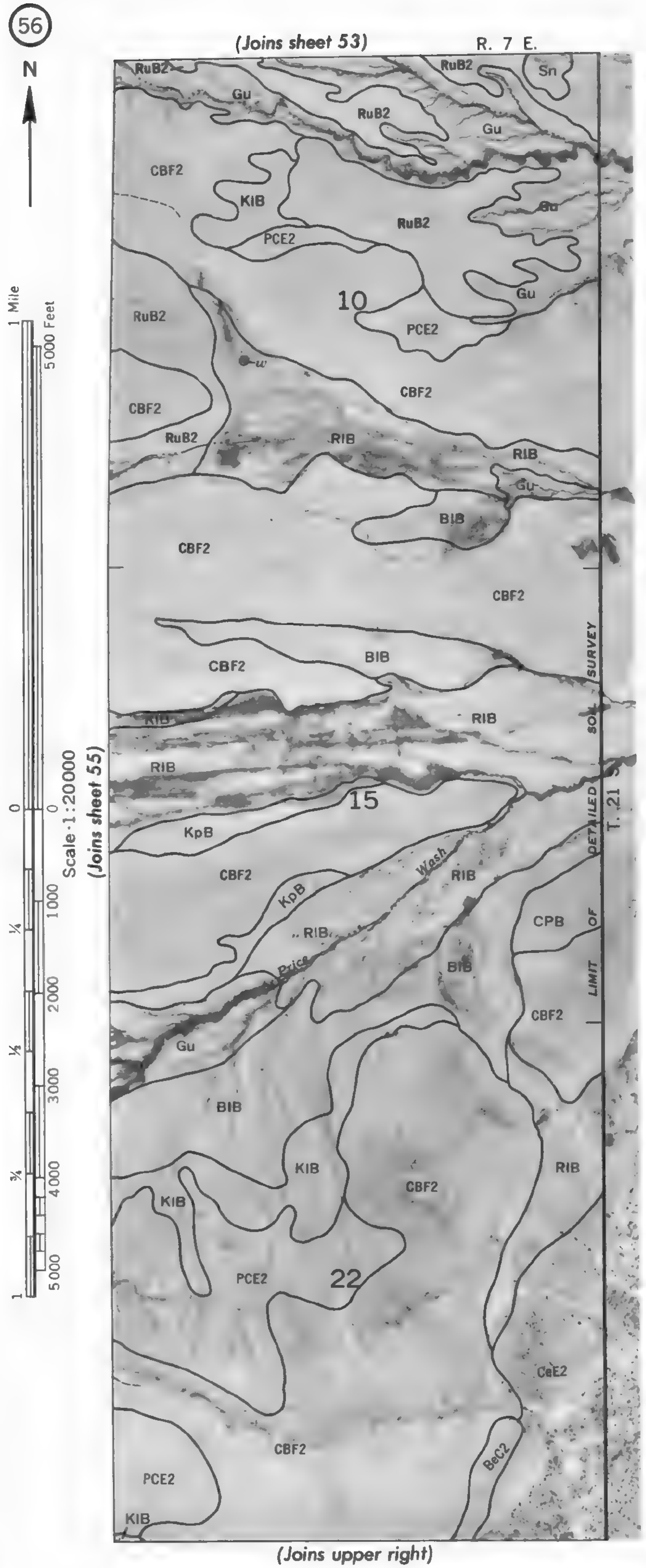
CARBON-EMERY AREA, UTAH NO. 54

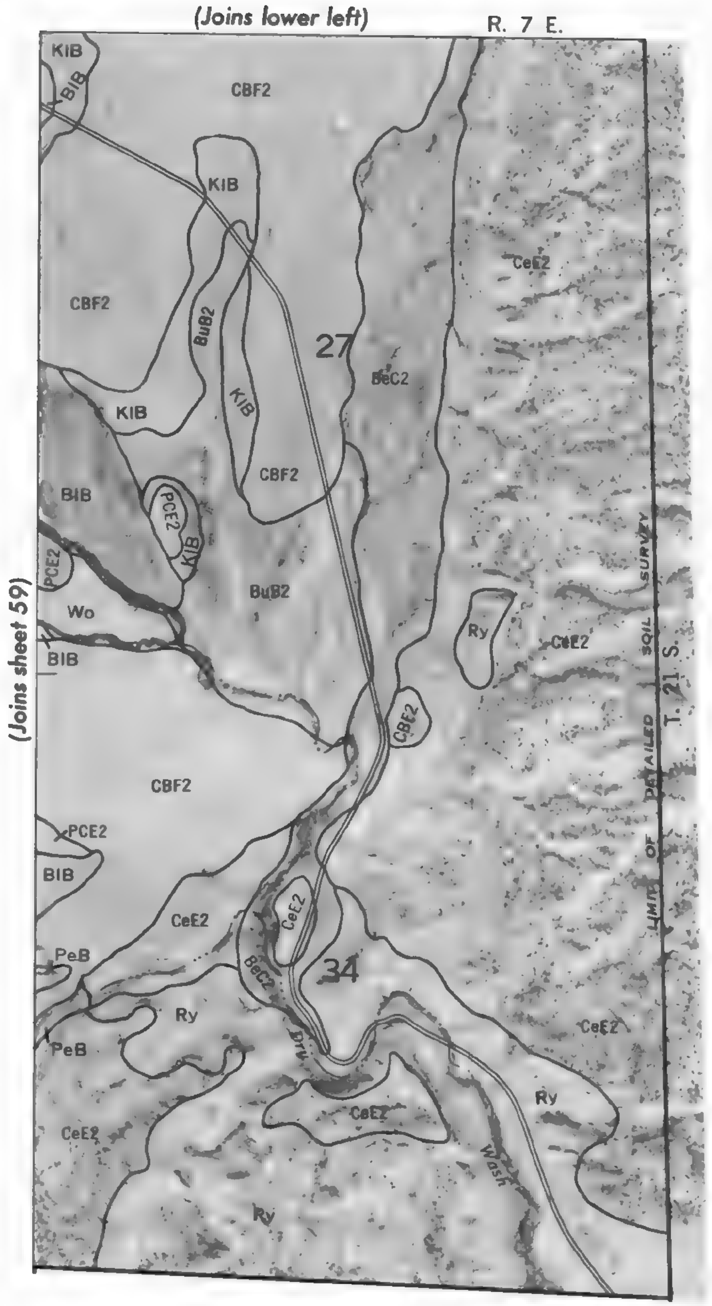
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

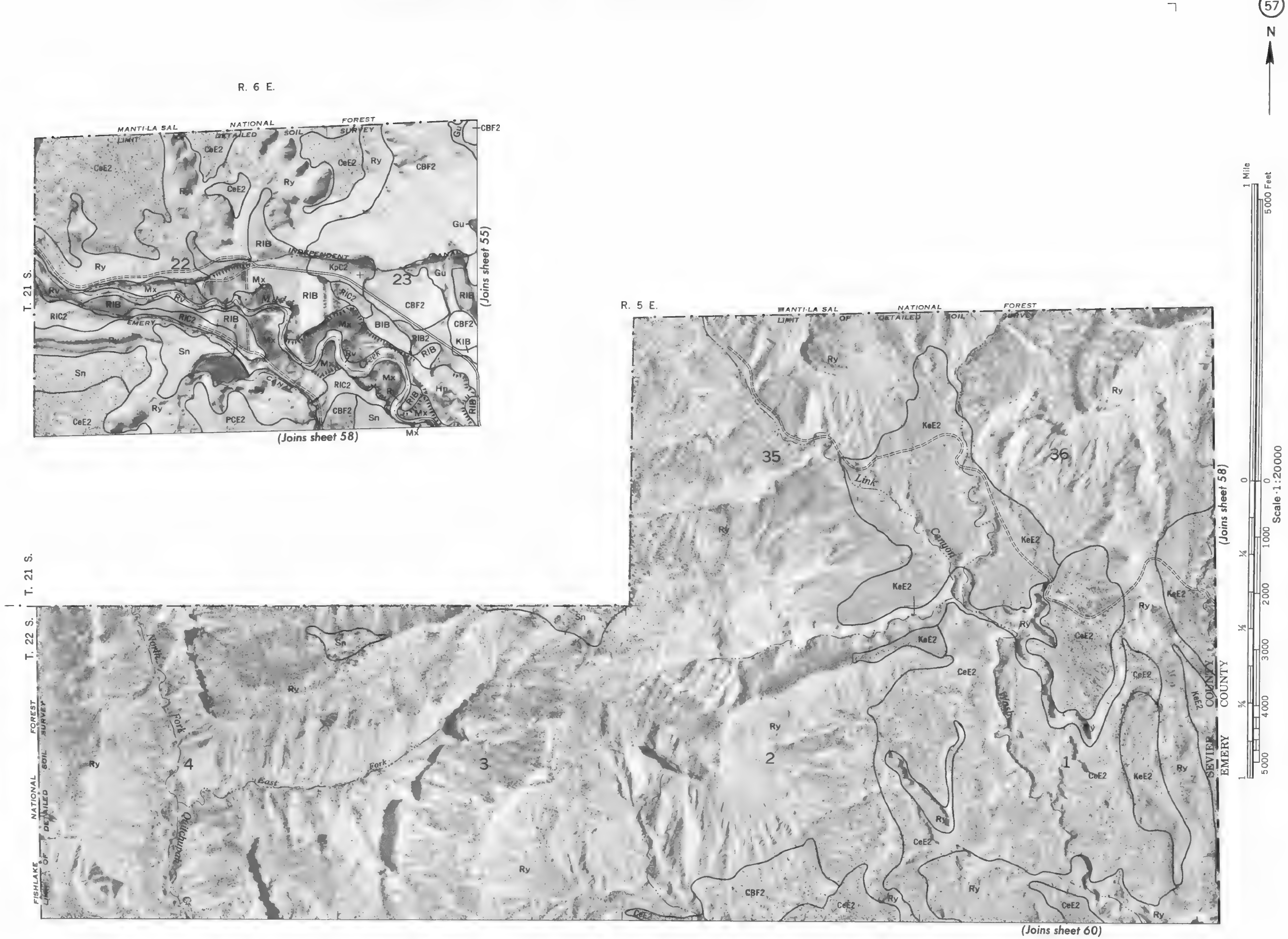



CARBON-EMERY AREA, UTAH NO. 56

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

N

1 Mile

5000 Feet

Scale 1:20000

0 ¼ ½ ¾ 1

0 1000 2000 3000 4000 5000


CARBON-EMERY AREA, UTAH NO. 58

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

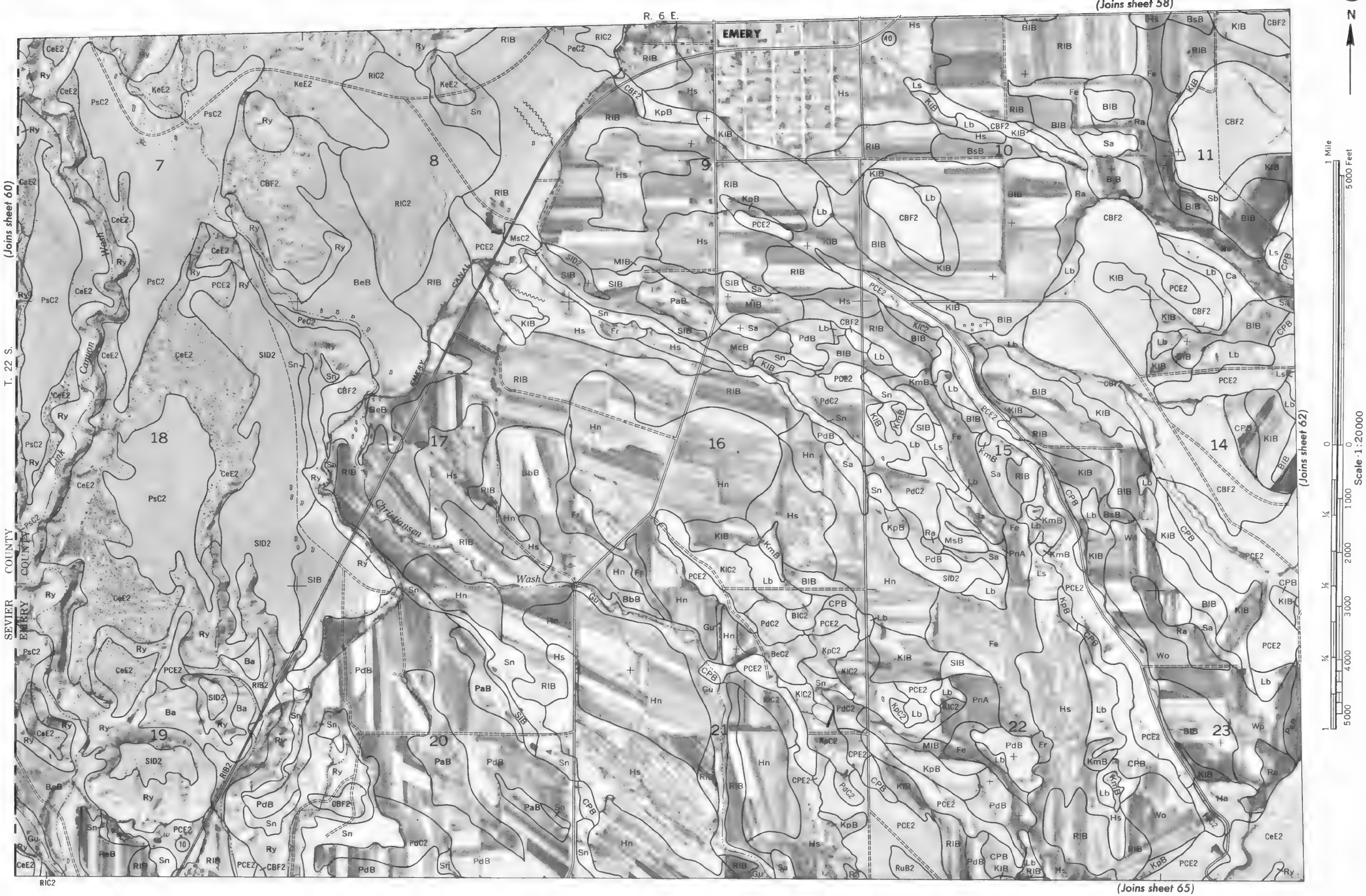

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

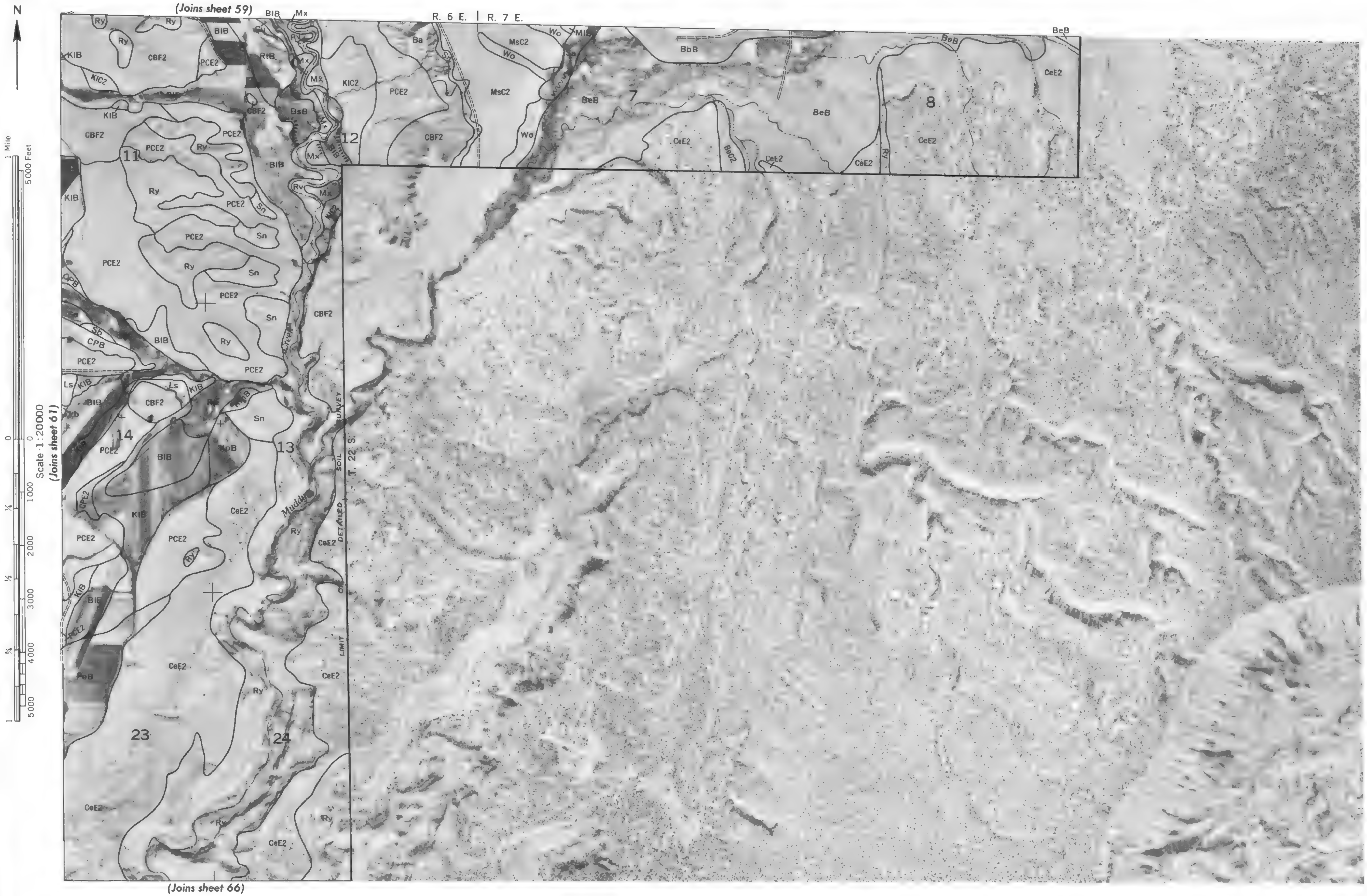
CARBON-EMERY AREA, UTAH — SHEET NUMBER 60


CARBON-EMERY AREA, UTAH NO. 60
Land division corners are approximately positioned on this map.
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

61




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

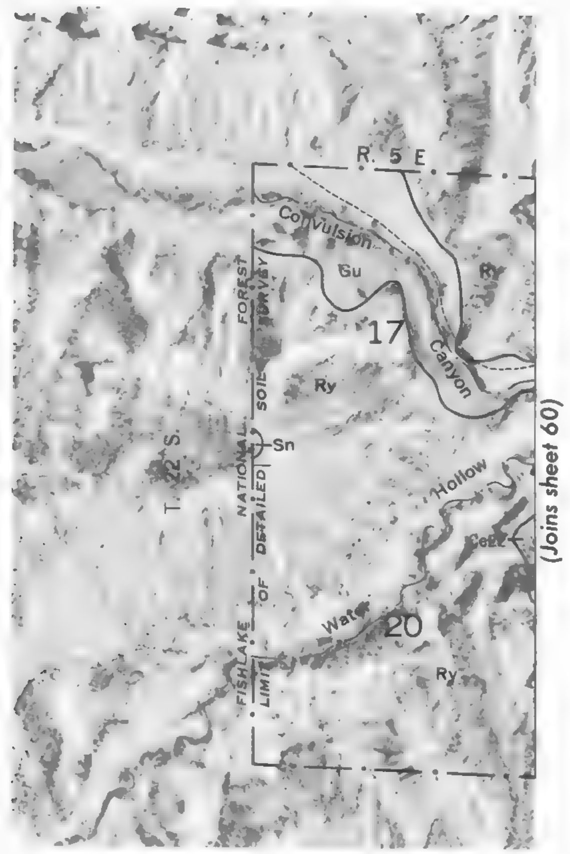


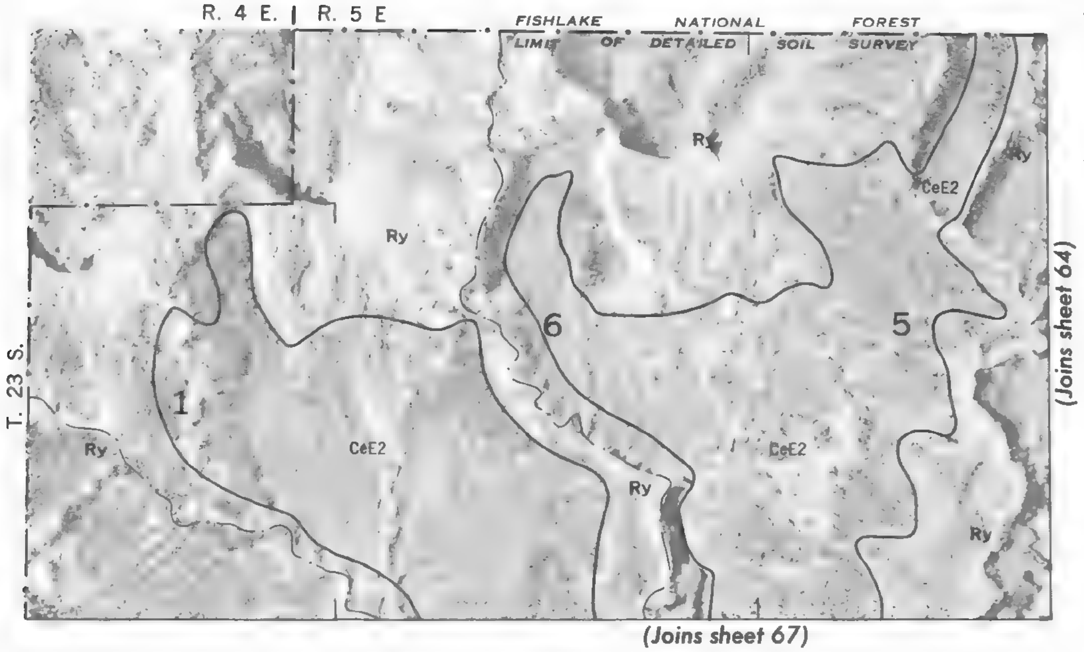

CARBON-EMERY AREA, UTAH NO. 62
Land division corners are approximately positioned on this map.
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

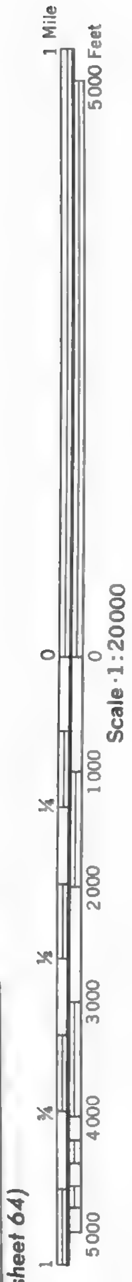
N

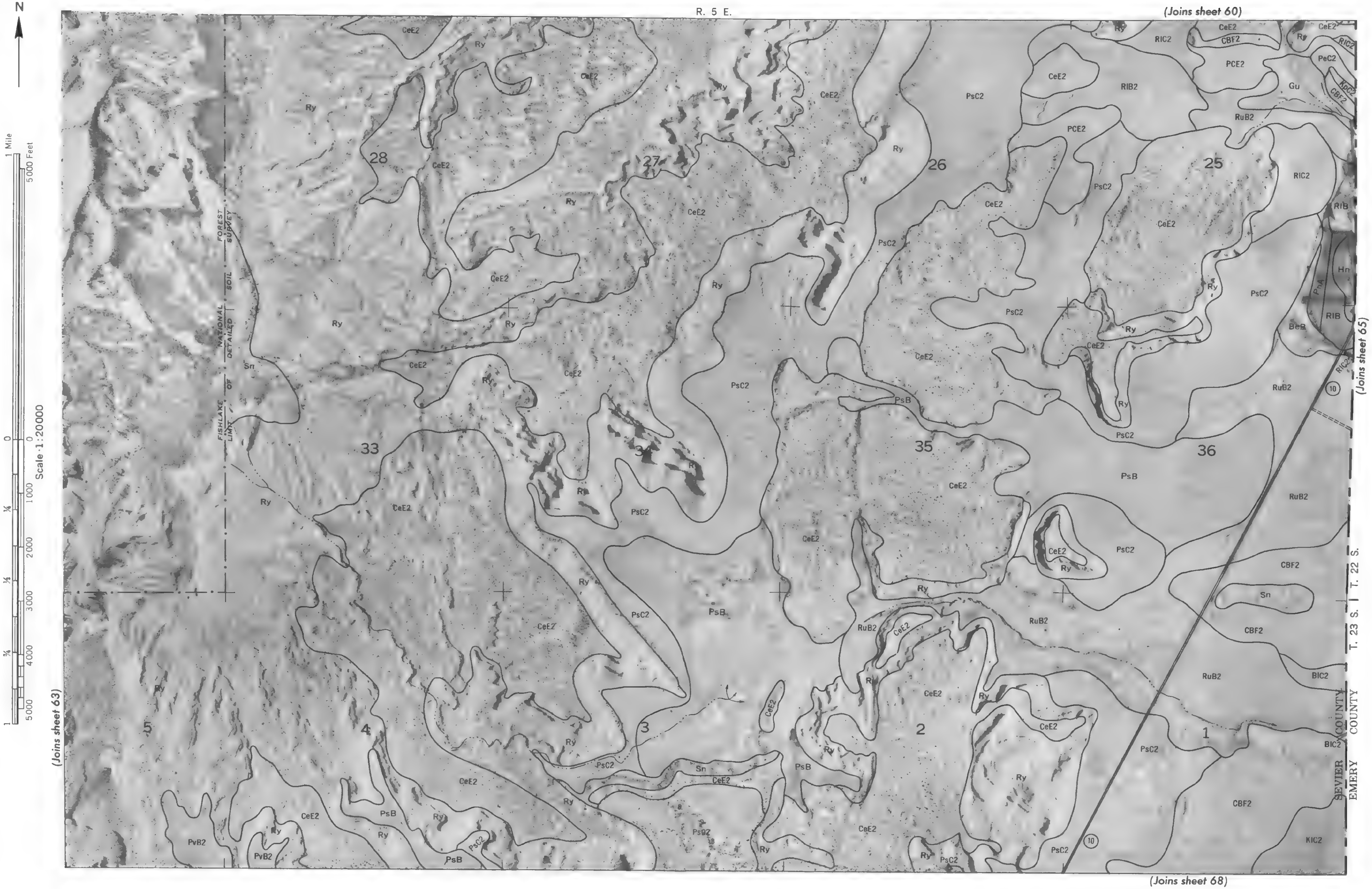
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.



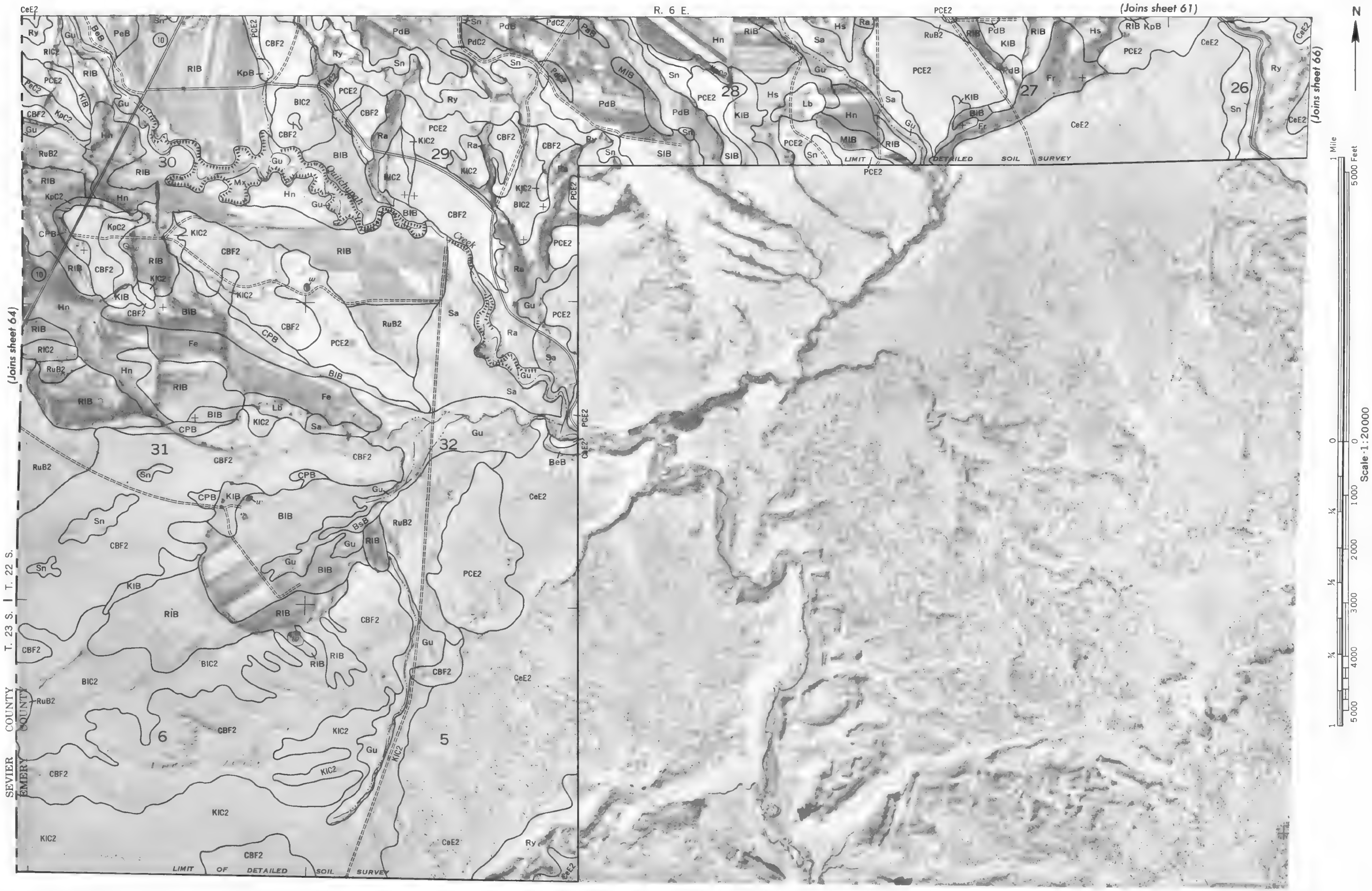





CARBON-EMERY AREA, UTAH NO. 64
Land division corners are approximately positioned on this map.
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 65

N

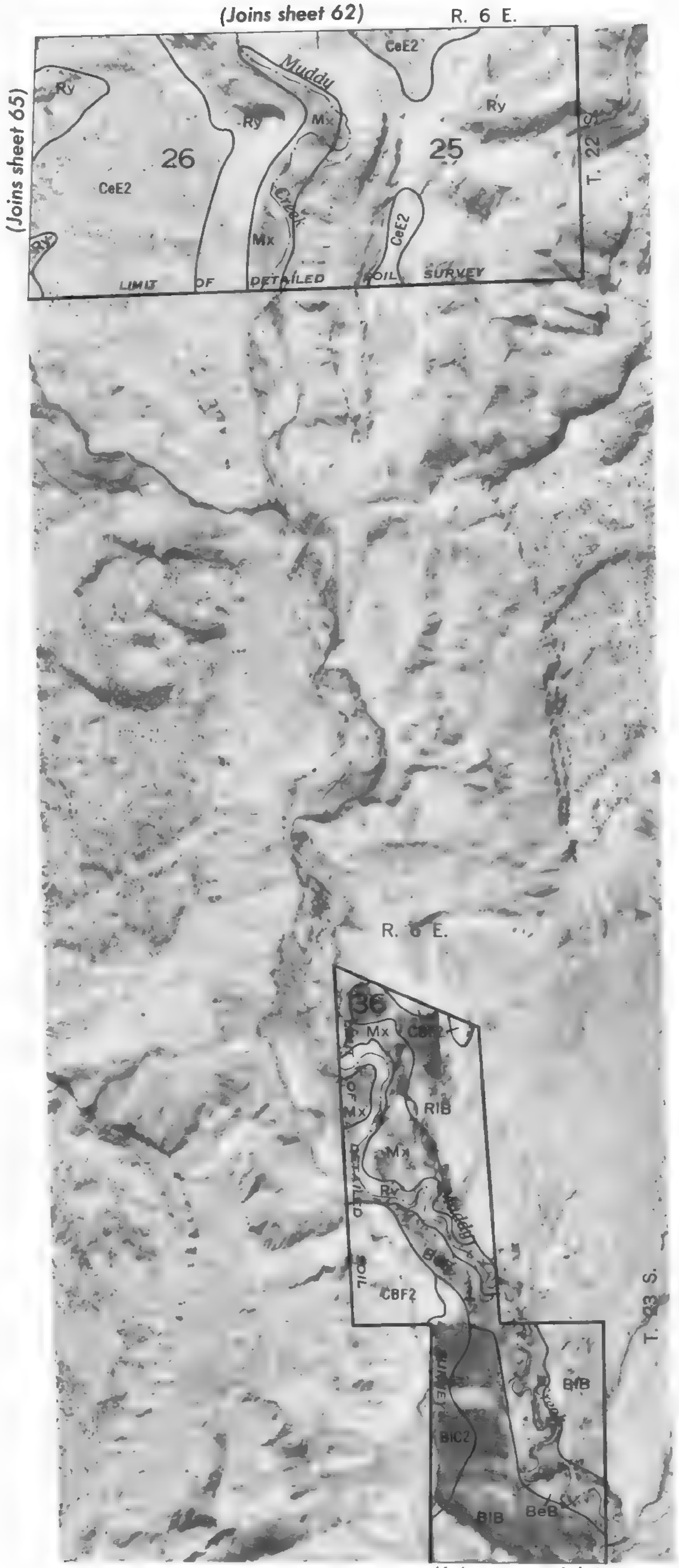
Scale 1:20000

1 Mile ¾ ½ ¼ 0

5000 Feet 5000 4000 3000 2000 1000 0

(Joins sheet 62)

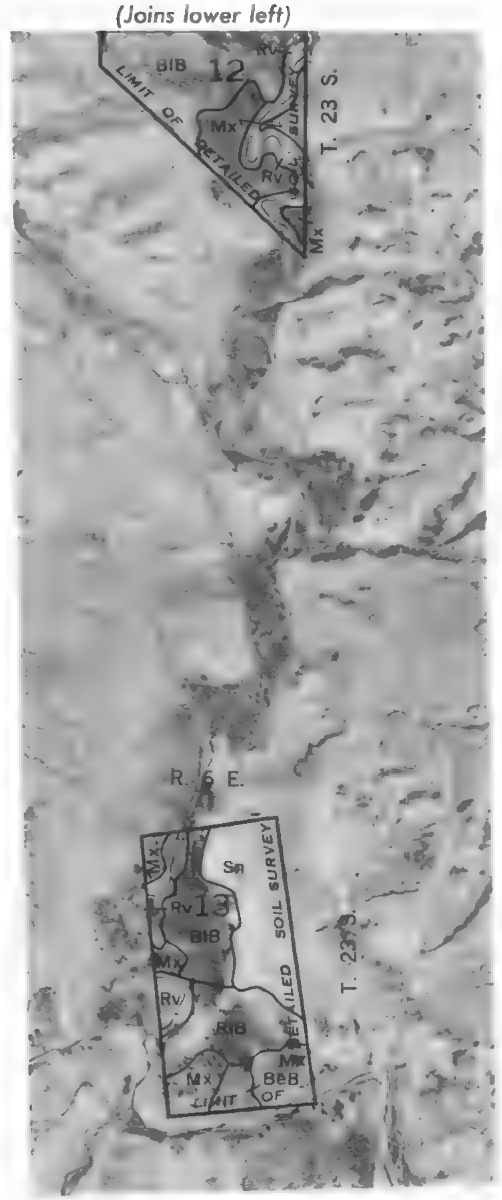
(Joins sheet 65)




(Joins upper right)

R. 6 E.

(Joins lower left)




CARBON-EMERY AREA, UTAH NO. 66

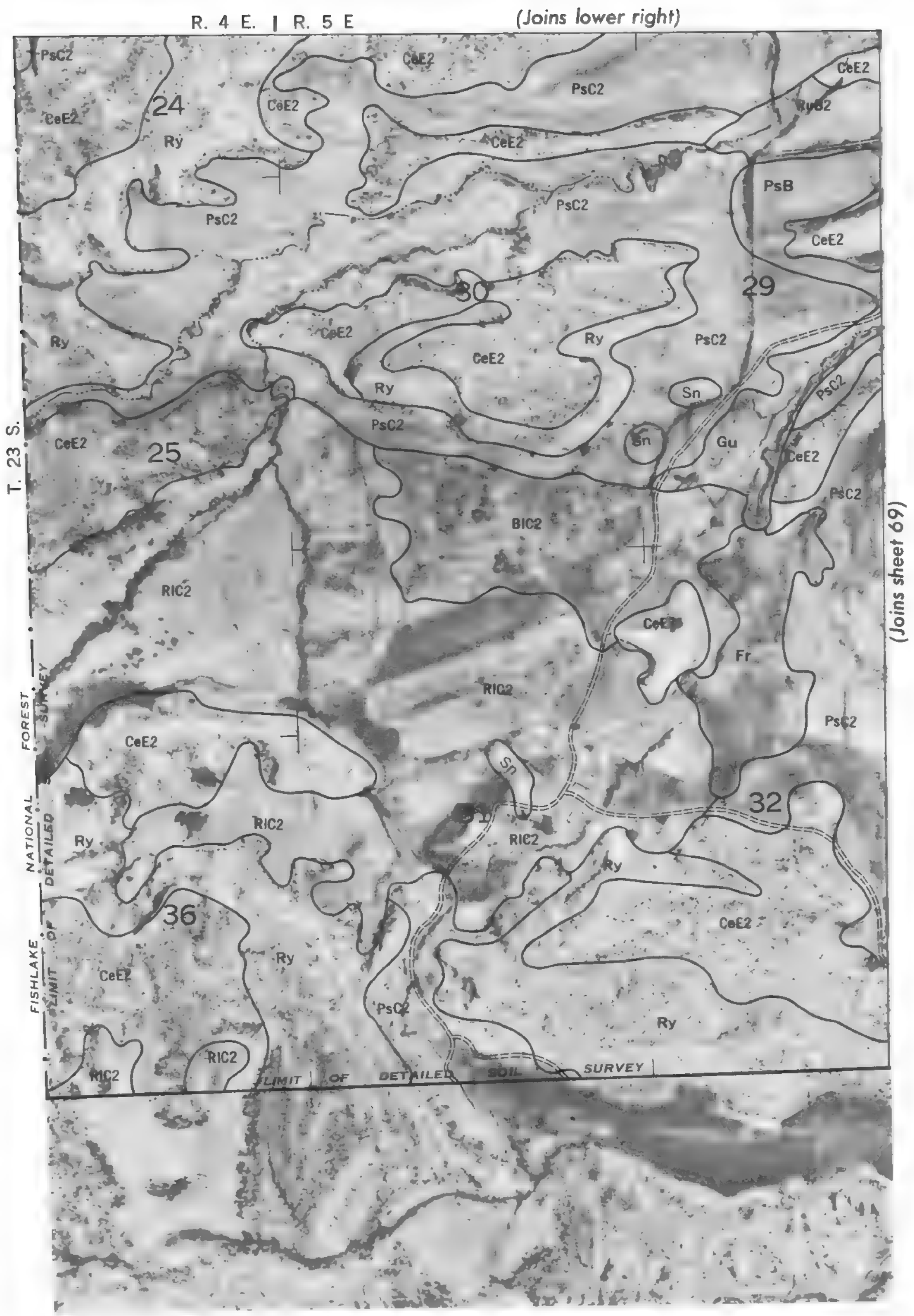
Land division corners are approximately positioned on this map.

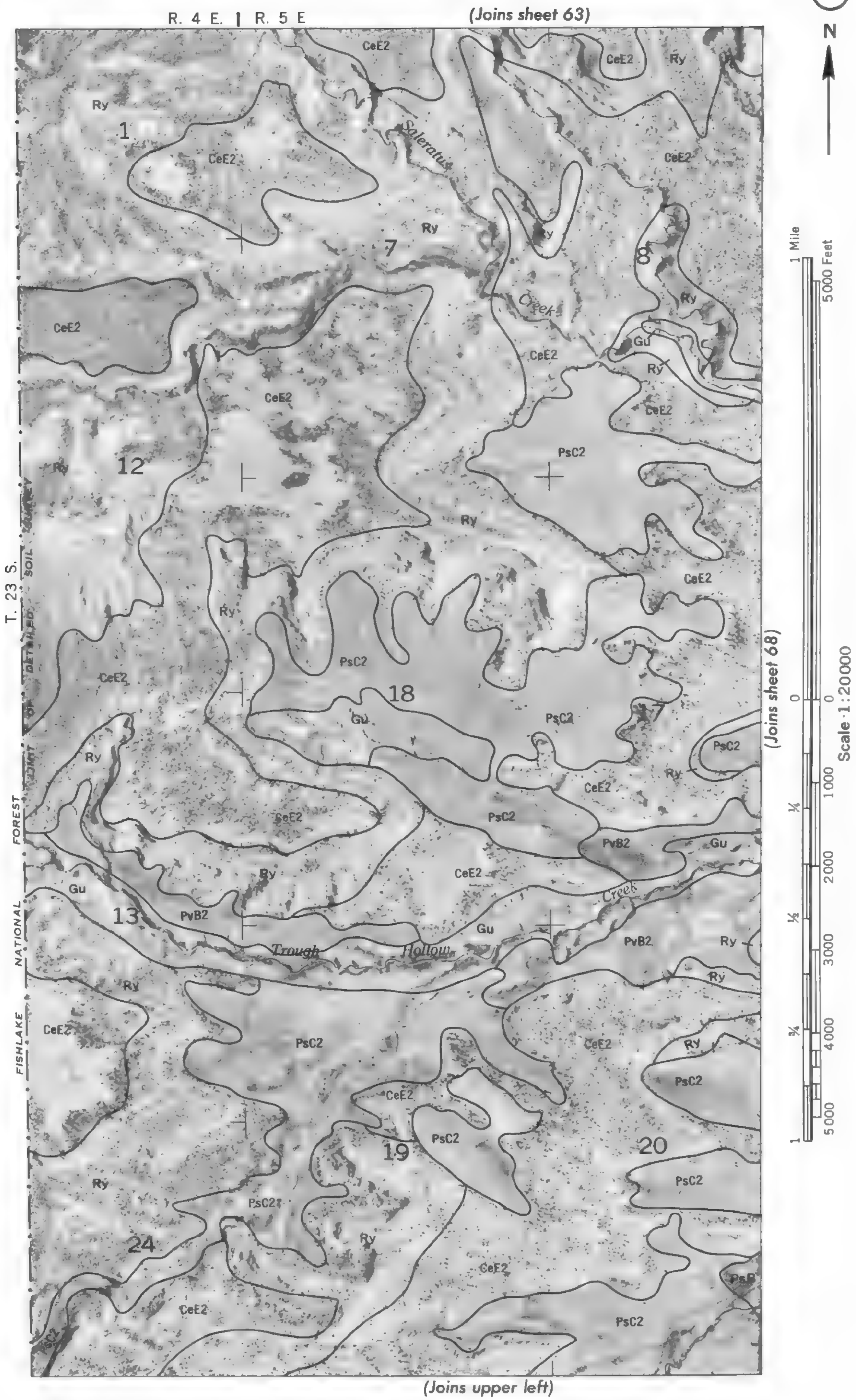
This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 67



CARBON-EMERY AREA, UTAH — SHEET NUMBER 68

N

Scale 1:20000

1 Mile | 5000 Feet | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | 0 | ¼ | ½ | ¾ | 1

(Joins sheet 64)

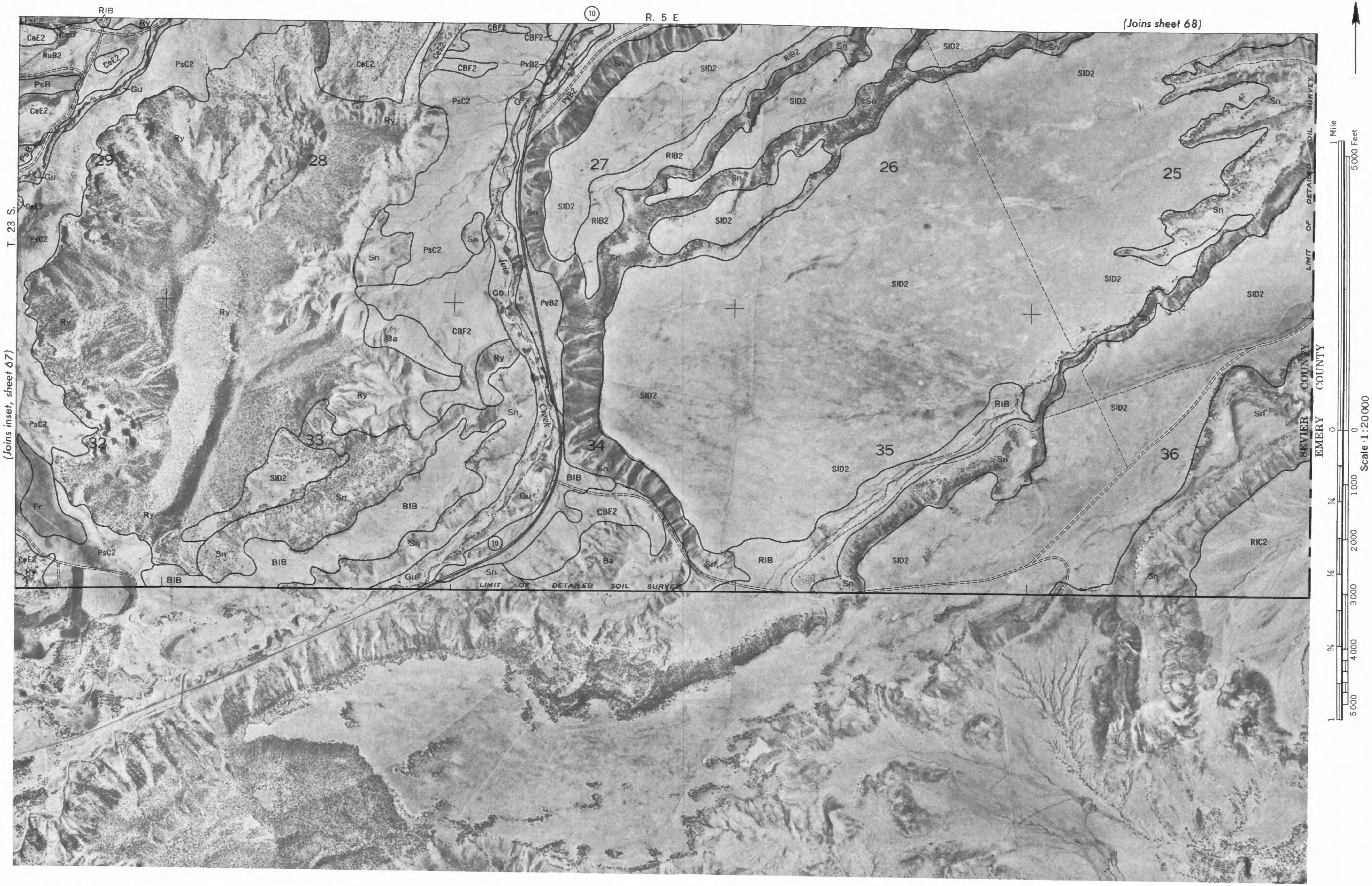
(Joins sheet 67)


(Joins sheet 69)

CARBON-EMERY AREA, UTAH NO. 68

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.




This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

Land division corners are approximately positioned on this map.

(70)

N

1 Mile
5000 Feet
Scale 1:20000
0 ¼ ½ ¾ 1
0 1000 2000 3000 4000 5000


(Joins sheet 71) Mx

CARBON-EMERY AREA, UTAH NO. 70

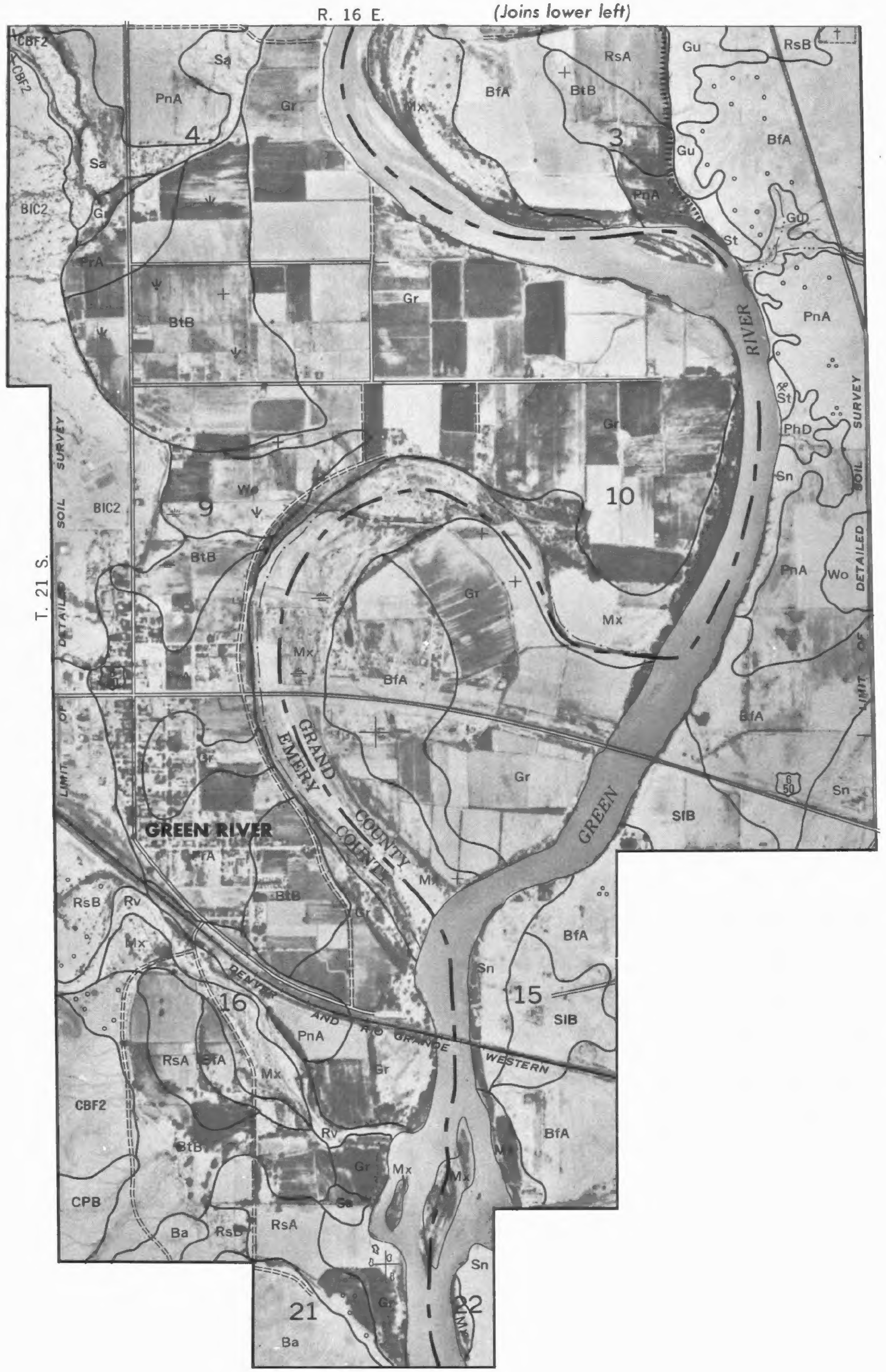
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.

(71)

This map is one of a set compiled in 1969 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, the Utah Agricultural Experiment Station, and United States Department of the Interior, Bureau of Land Management.
Land division corners are approximately positioned on this map.

CARBON-EMERY AREA, UTAH NO. 71


N

Scale 1:20000

1 Mile | 0 | ¼ | ½ | ¾ | 1

5000 Feet | 0 | 1000 | 2000 | 3000 | 4000 | 5000